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May 31, 2006

Mr. Jim Tischler
North Coast Water Board
5550 Skylane Boulevard, Suite A
Santa Rosa, California 95403

RE: Work Plan for Remedial Design Investigation
Former Unocal Facility # 2672
1075 Santa Rosa Avenue, Santa Rosa, California
ENSR Project Number 06940-268-130

Dear Mr. Tischler:

At the request of Union Oil Company of California (Unocal), ENSR Corporation (ENSR) has prepared this Work Plan to propose additional design investigation activities at 1075 Santa Rosa Avenue in Santa Rosa, California (Site) (see **Figure 1)**. This Work Plan proposes the use of membrane interface probe (MIP) technology to further delineate the extent of residual hydrocarbons and to evaluate soil physical properties. Findings from the proposed activities will assist ENSR in identifying new ozone sparge well locations that will be installed as part of remedial system improvements planned for the site.

Background

A Unocal service station operated at the site from 1946 through 1990. When constructed in 1946, the station facilities included two 2,000-gallon and two 4,000-gallon gasoline underground storage tanks (USTs), and one 285-gallon waste oil UST located in the southern portion of the site. In 1966, the station was demolished and rebuilt. Two 10,000-gallon gasoline USTs and one 250-gallon waste oil UST were installed in the central portion of the site. The 250-gallon waste oil UST installed in 1966 was removed in April 1989. The two gasoline USTs installed in 1966, product piping, and dispensers were removed in 1990 following station closure. The five original USTs installed in 1946 were removed in August 1992. The entire site is currently capped with concrete and asphalt. The site is currently an active automotive repair shop. Current and former site facilities are presented on **Figure 2**.

Site assessment activities began in 1989 and quarterly groundwater monitoring began in 1990. Remedial activities have included product recovery, soil excavation, soil vapor extraction, and ozone microsparging. To date, eighteen groundwater monitoring wells (MW-1 through MW-11, MW-12A/B through MW-14A/B, and MW-15), six soil borings (EB-1 through EB-6), three vapor extraction wells (VE-1 through VE-3), three CPT soil borings (CPT-1 through CPT-3), and ten air sparge wells (SP-1 through SP-10) have been installed at the site.

Site History

Information summarized in the following chronological history and discussion was obtained from PHR Environmental Consultants, Incorporated (PHR) report no. PHR119-003, *Phase 1 Environmental Site Assessment*, dated August 28, 1992, Kaprealian Engineering Incorporated (KEI) report no. KEI-P89-0106.R14, *Report of Vapor Extraction Well Installation*, dated September 26, 1994, Gettler-Ryan Inc. (G-R) report no. 280041, *First Quarter 2002 Groundwater Monitoring and Sampling Report,* dated March 7, 2002.

1946: Unocal constructed and began operating a service station at the site.

1965: December – A loss of approximately 1,376 gallons of gasoline from the USTs was reported.

1966: The station was demolished and rebuilt.

1989: February – KEI drilled soil borings EB-1 through EB-6, and installed groundwater monitoring wells MW-1 through MW-4 in borings EB-1 through EB-4, respectively.

April – One 250-gallon of waste oil UST was removed.

June – Quarterly monitoring and sampling was initiated at the site by MPDS Services, Incorporated.

November – KEI installed monitoring wells MW-5 and MW-8 through MW-10.

1990: January – Free product (FP) up to 13 feet thick, was discovered in two on-site wells. Semi-weekly bailing was initiated, which reduced the amount of FP to trace levels within three weeks.

February – The super unleaded product line failed a tightness test and was repaired. FP bailing was reduced in frequency to weekly.

May – KEI installed groundwater monitoring wells MW-6, MW-7, and MW-11.

November – Station was permanently closed.

December – Two 10,000 gallon USTs, product lines, and dispensers were removed and over-excavation of impacted soil was conducted.

1992: February – FP bailing was reduced in frequency to biweekly.

June – KEI attempted to install a recovery well in the former UST area, but was unable due to heavily impacted fill material encountered at approximately 10 feet below ground surface (bgs) and groundwater with FP.

August – Five USTs originally installed in 1946 were removed and over excavation of impacted soil was conducted.

1993: May – KEI installed vapor extraction well VE-1. No FP was noted in the well.

June – KEI conducted a 48-hour vapor extraction test.

1994: June – KEI installed vapor extraction wells VE-2 and VE-3.

October – A vapor extraction system (VES) was installed and began operation.

1997: September – The VES system was shut down. A total of 6,413 pounds of total petroleum hydrocarbons as gasoline (TPHg) and 63.2 pounds of benzene were extracted by the system. System operation was severely impaired by the screened intervals in the extraction wells being partially to completely submerged.

1998: January – G-R assumed quarterly monitoring and sampling at the site.

1999: August – G-R installed a low-flow oxygen enhancement system to inject oxygen under low pressure into the existing vapor extraction wells.

2003: July – Three cone penetrometer test borings were advanced to approximately 80 feet bgs each. Depth discrete groundwater samples were collected to assist in assessing extent of petroleum impact.

September – G-R installed 10 sparge wells in preparation for the installation of an ozone micro-sparge system.

November – An ozone micro-sparge system was installed and began operation.

2004: Between April 27, 2004 and May 6, 2004, ENSR installed groundwater monitoring well MW-15 to 20 feet bgs, and advanced three soil borings to 85 feet bgs. The soil borings were completed as nested monitoring wells MW-12A/B, MW-13A/B, and MW-14A/B.

June – The ozone micro-sparge system was shut down as a result of the presence of volatile organic compound (VOC) vapors escaping from various C-Sparge™ points, monitoring wells, and PVC conduits that house the C-Sparge™ HDPE lines.

2005: May - ENSR installed a small soil vapor extraction (SVE) system to abate the escaping VOCs from the ozone micro-sparge system after receiving approval from the North Coast Water Board.

June - The SVE system became fully operational under a Bay Area Air Quality Management District (BAAQMD) operating permit for plant number 16288. The ozone micro-sparge system was restarted.

December – ENSR conducted two multiphase extraction (MPE) pilot tests using monitoring well MW-4 as an extraction well on December 8 and 15, 2005. Each test lasted approximately six hours. The cumulative TPHg and benzene mass removed from the groundwater during the two MPE pilot tests was calculated to be 0.56 pounds and 0.02 pounds, respectively. The cumulative VOC mass removed from the vapor phase during the two MPE pilot tests was estimated as 2.8 pounds.

2006: ENSR has been conducting routine emission monitoring of the SVE system and operation maintenance of the ozone micro-sparging system since June 2005.

Groundwater Sampling

In the First Quarter 2006 monitoring event, TPHg was detected in six wells, ranging from 140 micrograms per liter (µg/L) in well MW-7, to 310,000 µg/L in well MW-4. Benzene was detected in six wells, ranging from 2.6 µg/L in well MW-7 to 2,300 µg/L in well MW-4. MTBE was detected in five wells, ranging from 1.2 µg/L in well MW-1 to 150 µg/L in well MW-2. TBA was detected in well MW-11 only at 7.2 µg/L. 1,2-DCA was detected in wells MW-12A, MW-13A, and MW-14A ranging from 0.57 µg/L to 16 µg/L. Petroleum hydrocarbon constituents above the laboratory reporting limits were not detected in nine wells (MW-6, MW-9, MW-10, MW-12A, MW-12B, MW-13A, MW-13B, MW-14B, and MW-15) during the first quarter 2006.

Geologic and Hydrologic Setting

Soil types encountered beneath the site consisted of clay to silt to approximately 17 feet bgs. Coarser materials consisting of clayey gravel are encountered from approximately 17 to 26 feet bgs. Interbedded layers of silt and sandy silt underlie the coarser grained materials and extend to approximately 50 feet bgs. At approximately 45 feet bgs an increase in sand percentage was encountered and graded from fine to coarse sand to fine to coarse gravel with clay to 65 feet bgs. A layer of clay to silt is encountered from 65 to 70 feet bgs and is underlain by interbedded layers of sand, sand and gravel, and silty sand to the depth of 85 feet bgs.

Proposed Activities

Task One – Pre-field Activities:

Pre-field activities include preparation of a site specific Health and Safety Plan and a Job Safety Analysis, obtaining necessary permits, and scheduling a C-57-licensed drilling contractor to perform assessment activities under the direction of an ENSR field geologist. The proposed boring locations will be marked in white spray paint and ENSR will contact Underground Service Alert North at least 48 hours prior to commencement of field activities for location and marking of underground utilities within the work area. ENSR will also contract a private utility locator to clear the proposed boring locations prior to drilling.

Task Two – Field Activities - MIP Survey and Confirmation Soil Borings:

Field activities will be performed by an ENSR geologist under the supervision of a California professional geologist (PG). ENSR staff will supervise the clearing of the MIP and confirmation boring locations with an air knife to a minimum depth of eight feet prior to drilling. ENSR proposes to advance up to 19 MIP borings (MIP-1 through MIP-19) in the known or suspected hydrocarbon-impacted areas at the Site to be followed by 4 confirmation soil borings for verification of MIP results. **Figure 3** shows the proposed boring locations. Proposed MIP borings and confirmation soil borings will be advanced by a California-licensed drilling subcontractor utilizing direct push drilling technology to advance MIP logging and soil sampling equipment. ENSR standard operating procedures (SOP) for MIP boring and logging procedures are provided in **Appendix A**. ENSR SOP for direct push confirmation soil boring installation and soil sample collection are provided in **Appendix B.**

MIP is a direct push screening tool that produces a continuous log of vadose zone and saturated soils based on electrical conductivity responses and relative impacts by volatile organic compounds (VOCs). ENSR will use these data to locate and estimate the remaining hydrocarbon mass, and to further define the subsurface lithology. The total depth of each MIP boring is anticipated to range from 40 to 45 feet bgs depending on site conditions encountered. ENSR boring logs (**Appendix C**) indicate an aquitard is present between depths of 30 to 50 feet bgs. Groundwater is anticipated to be encountered at approximately 8 to 10 feet bgs. The scope of work may be expanded based on MIP data as it is collected to adequately delineate the extent of impacts. Following MIP drilling, cross-sections and maps will be generated to assist in evaluating the extent of petroleum hydrocarbon impacts and in selecting locations for additional ozone sparge well locations.

Four confirmation borings (MC-1 through MC-4) will be advanced adjacent to the MIP borings, and soil samples will be collected at various depths, based on MIP data, using direct push technology. Soil samples will be collected from the MIP-identified petroleum hydrocarbon impacted zone(s) using continuous core samplers fitted with acetate liners. Dual-tube Geprobe equipment is proposed to reduce potential for cross-contamination and for borehole stability. Soils encountered in the borings will be described by an ENSR geologist using the Unified Soil Classification System (USCS) visual and manual methods, in accordance with the American Society for Testing and Materials (ASTM) Standard D2488-00 the Munsell Soil Color Charts. It should be noted that ENSR's use of the USCS visual and manual methods does not imply conformance with other related ASTM Standards referenced therein.

Soil samples will be field screened for volatile organic compounds (VOCs) using a PID to conduct head-space analysis. Field screening using a PID will also be conducted where visible staining or signs of impact are observed, at changes of lithology, and where the moisture content of the soil changes (e.g., in the capillary fringe zone above groundwater or within the saturated zone). Geologic descriptions and PID readings will be recorded on the soil boring logs at the appropriate depths. The samples will be stored on ice and transported in appropriate containers pending submittal to a laboratory for analysis under chain-of-custody protocol.

The MIP results and PID and other field data will be reviewed by the geologist to select samples for laboratory analysis. Samples selected for analysis will include the soil samples to verify MIP data, samples with elevated PID measurements, at significant lithologic contacts, at the groundwater-vadose zone interface, and total depth in each boring. Data will be used to further delineate the lateral and vertical extent of hydrocarbons and estimate the remaining hydrocarbon mass in soils.

MIP and confirmation soil borings will be backfilled with neat cement to surface grade upon completion. Representative sample (s) will be collected from soil cuttings and rinsate and equipment decontamination water generated during drilling and submitted to a California State certified laboratory for waste characterization.

Task Three – Laboratory Analysis:

ENSR will submit selected soil samples for laboratory chemical analysis to a laboratory certified by the California Department of Health Services under chain-of-custody protocols. Soil and groundwater samples will be analyzed for TPHg, benzene, toluene, ethylbenzene, total xylenes, and MTBE by United States Environmental Protection Agency Method 8260B.

Soil samples from borings MC-1 through MC-4 will also be collected for physical testing in order to provide geotechnical property parameters to assess petroleum hydrocarbon fate and transport and constraints on site remediation. Soil samples for physical testing will be collected in sections of 1.5 to 2-inch acetate sleeves, capped with Teflon sheeting and tight fitting plastic end caps and will be transported to Sierra Testing Laboratory, Inc. in El Dorado Hills, California. Samples will be collected at 3- to 5-foot intervals and evaluated for selection of physical testing parameters based on chemical analytical results as well as lithologic relevance to ozone sparging.

The soil samples for physical testing parameters will be tested for particle size determinations by ASTM Method D-422, moisture density determinations by ASTM Method D-2937, flexible wall vertical permeability by ASTM Method D-5084, specific gravity determinations by ASTM Method D-854, and moisture content by ASTM Method D-2216. Atterberg limits will be determined by ASTM Method D-4318.

Task Four – Waste Containment and Disposal:

Soil cuttings, and rinsate generated during drilling and sampling activities will be profiled, sealed in United Nations-approved 55-gallon drums, labeled, and stored on site pending analysis. Upon characterization, soil and purge water will be transported to a proper disposal facility for disposal under approved and applicable protocols.

Task Five – Reporting and Recommendations:

Following the field activities, ENSR will submit a report documenting the investigation results. The report will include field observations, boring logs, laboratory results, conclusions, and recommendations for further site remedial activities, including additional locations of ozone sparge wells. The report will be prepared under the supervision of and signed by a California Professional Geologist. ENSR will also submit all required electronic files necessary to comply with State GeoTracker requirements.

Schedule

ENSR will initiate activities upon receiving authorization to proceed. The proposed work including the report is estimated to take approximately 60-90 working days to complete with the following assumptions:

- Analytical results are available in a standard turn-around time (two weeks from submittal),
- Permits are obtained within two weeks of submitting an application and fees, and
- Drilling subcontractor is available on a timely basis.

Remarks/Signatures

The interpretations contained in this document represent our professional opinions, and are based in part on information supplied by the client. These opinions are based on currently available information and are arrived at in accordance with currently accepted hydrogeological and engineering practices at this time and location. Other than this, no warranty is implied or intended.

ENSR appreciates the opportunity to provide Unocal with our professional environmental consulting services. If you have any questions regarding this Work Plan or if we can be of further service, please do not hesitate to contact Mike Berrington at (916) 362-7100.

Sincerely,

Forrest McFarland P.G. #7984
Project Geologist

Mike Berrington, P.G.# 7124
Project Manager

PROFESSIONAL GEOLOGIST
MICHAEL A. BERRINGTON
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Senior Project Manager

PROFESSIONAL GEOLOGIST
MARK CAPPS
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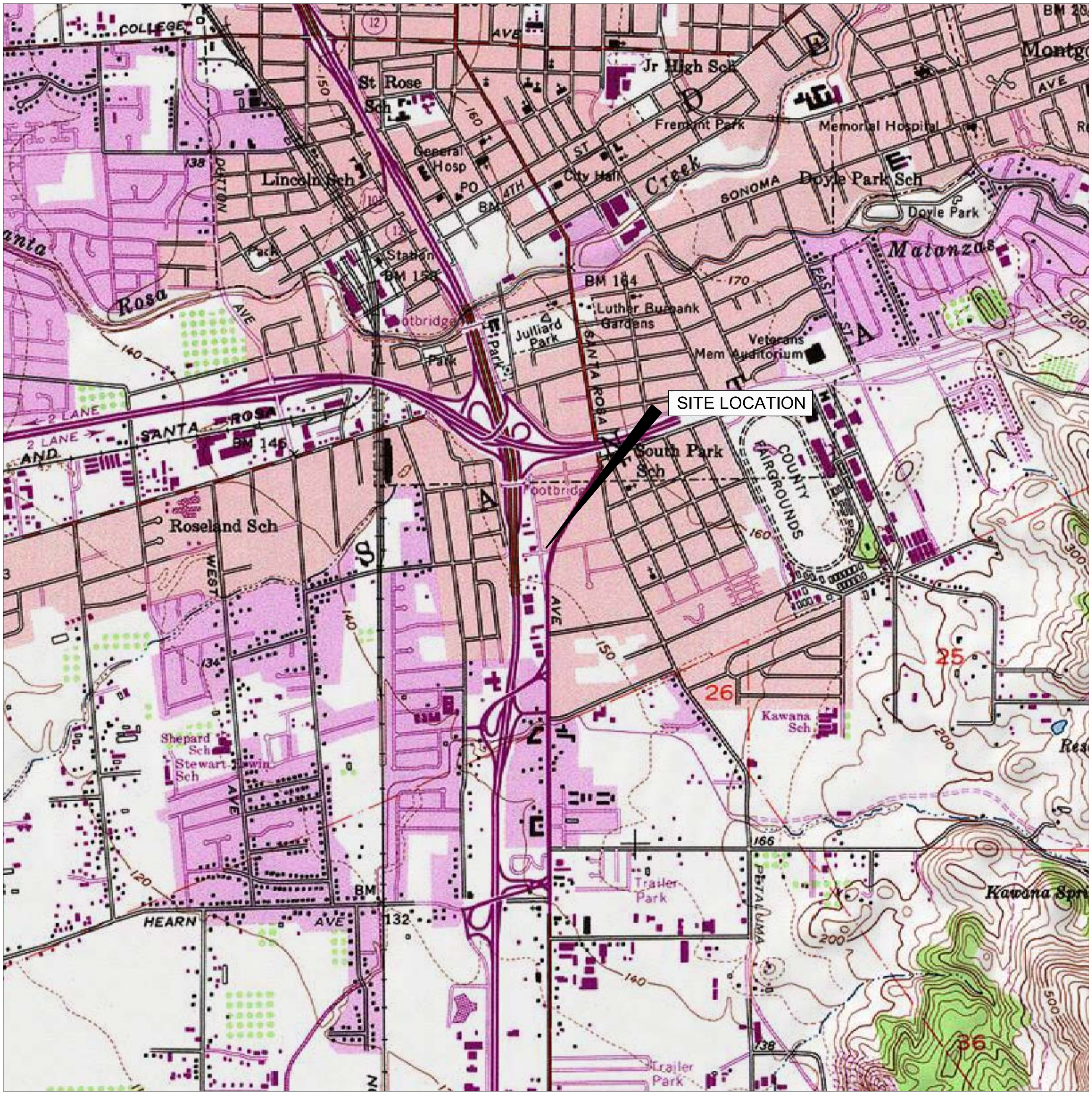
STATE OF CALIFORNIA

cc: Mr. John Frary, Union Oil Company of California
Mr. Vincent Spiers, Site Owner
Santa Rosa Fire Department

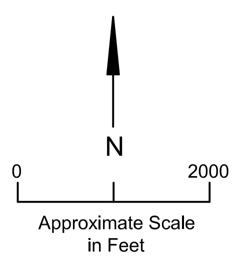
Figures:
1 - Site Location Map
2 - Site Plan
3 - Proposed Boring Locations

Appendices:
A - ENSR Field Methods and Procedures
B - MIP Methods and Procedures
C - Boring Logs

Figures



Map created with TOPO - 2003 National Geographic



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SITE LOCATION MAP

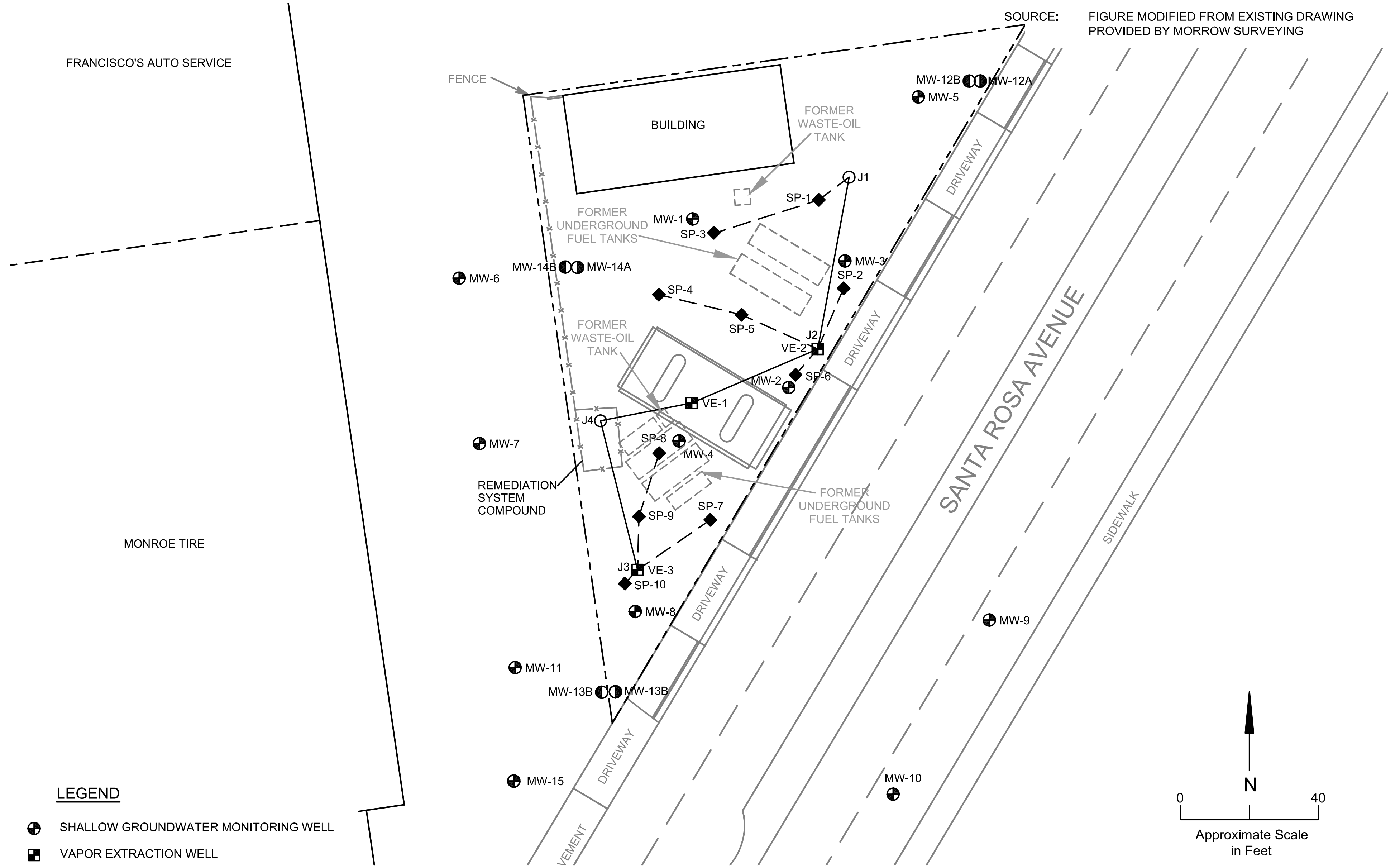
MIP WORK PLAN 2006
FORMER UNOCAL STATION 2672
1075 SANTA ROSA AVENUE
SANTA ROSA, CALIFORNIA

FIGURE NUMBER:
1

DRAWN BY:	DATE:	PROJECT NUMBER:	SHEET NUMBER:
E. COWAN	03/23/06	06940-268-100	X

2672 SLM MIP 2006

2672 SITE PLAN MIP 2006



LEGEND

- SHALLOW GROUNDWATER MONITORING WELL
- VAPOR EXTRACTION WELL
- OZONE SPARGE POINT
- INTERMEDIATE MONITORING WELL
- DEEP MONITORING WELL
- 2" BELOW GROUND CONDUIT SCHEDULE 40 PVC
- 6" BELOW GROUND CONDUIT SCHEDULE 40 PVC
- J4 36" JUNCTION BOX

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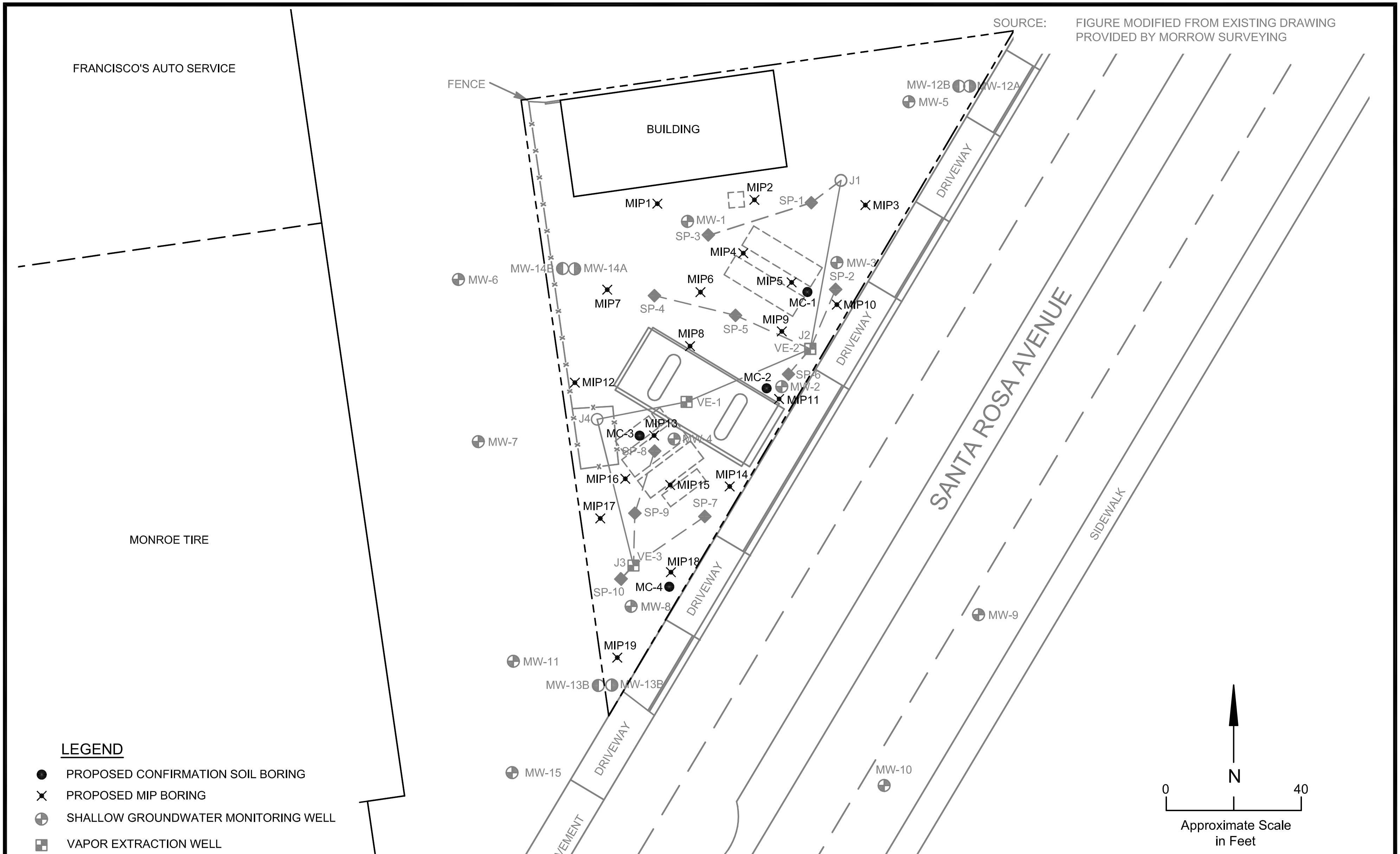
SITE PLAN

MIP WORK PLAN 2006
FORMER UNOCAL STATION 2672
1075 SANTA ROSA AVENUE
SANTA ROSA, CALIFORNIA

FIGURE NUMBER:
2

DRAWN BY:	DATE:	PROJECT NUMBER:	SHEET NUMBER:
E. Cowan	03/23/2006	06940-268-100	X



LEGEND

- ● PROPOSED CONFIRMATION SOIL BORING
- ✕ PROPOSED MIP BORING
- SHALLOW GROUNDWATER MONITORING WELL
- VAPOR EXTRACTION WELL
- OZONE SPARGE POINT
- INTERMEDIATE MONITORING WELL
- DEEP MONITORING WELL
- 2" BELOW GROUND CONDUIT SCHEDULE 40 PVC
- 6" BELOW GROUND CONDUIT SCHEDULE 40 PVC
- J4 ○ 36" JUNCTION BOX

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PROPOSED BORING LOCATIONS

MIP WORK PLAN 2006
FORMER UNOCAL STATION 2672
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SANTA ROSA, CALIFORNIA

FIGURE NUMBER:
3

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Appendix A
MIP Field Methods and Procedures

Subsurface Soil Sampling by Geoprobe™ Methods

Date: 2nd Qtr. 1995
Revision Number: 0
Author: Charles Martin
Discipline: Geoscience

1.0 INTRODUCTION

1.1 Purpose and Applicability

This Standard Operating Procedure (SOP) describes the methods available for collecting subsurface soil samples using commercially available Geoprobe™ Systems (or other similar vendor) soil probing equipment. Subsurface soil samples may be obtained using this system for purposes of determining subsurface soil conditions and for obtaining soil samples for physical and/or chemical evaluation.

The purpose of this SOP is to provide a description of a specific method or procedure to be used in the collection of subsurface soil samples using the Geoprobe™ system. Subsurface soil is defined as unconsolidated material which may consist of one or a mixture of the following materials: sand, gravel, silt, clay, peat (or other organic soils), and fill material. Subsurface soil sampling, conducted in accordance with this SOP will promote consistency in sampling and provide a basis for sample representativeness.

This SOP covers subsurface soil sampling using Geoprobe™ Systems equipment; specifically, the Macro-Core Soil Sampler, and the Large Bore Sampler. Use of this sampling equipment requires use of the Geoprobe™ hydraulically-powered percussion/probing machine. Geoprobe™ sampling is usually performed by subcontractors, although rental equipment is available for use by trained operators.

The Geoprobe™ sampling methods covered in this SOP are applicable to unconsolidated soil/fill materials and to a maximum recommended depth of approximately 30 feet. Sampling depths are greatly dependent upon soil density as the hydraulically-powered probing unit has power limitations. Sample recovery is also somewhat dependent on grain size as very coarse gravel, cobbles, and boulders will occasionally cause premature refusal of the sampler. It is generally preferable to have some prior knowledge of site soil conditions if sampling activities are proposed where equipment limitations may become a factor.

Other types of equipment and sampling methods are available for use in obtaining samples of unconsolidated materials; and include split-spoons, Shelby tubes, and continuous core barrel samplers. Information on these and other soil sampling devices may be found in other ENSR SOPs, ASTM procedures, drilling handbooks, and respective state and/or federal agency technical guidance documents.

1.2 General Principles

Soil sampling using the Geoprobe™ System requires use of the hydraulically-powered percussion/probing machine and either the Macro-Core Soil Sampler or the Large Bore Sampler soil sampling devices. The percussion/probing machine is typically mounted onto the bed of a pickup truck or van so that a stable working platform is established. The percussion/probing machine, through its hydraulic operation, pushes and hammers the soil sampling equipment vertically into the ground within the targeted sampling interval. The soil sampler is then extracted from the ground to recover the sample.

The Macro-Core Sampler (Figure 1) consists of a 45-inch long by 1.5-inch diameter open-ended steel sampling tool with liners made of clear plastic (cellulose acetate butyrate), stainless steel, or teflon. The tool is designed for use in a continuous sampling capacity in an open borehole up to depths of approximately 24 feet. The borehole walls are required to stay open in order to collect a sample from the next depth interval. Once the sampling tool is removed from the ground, the inserted liner containing the soil sample is removed from the tool. The soil sample is then cut from or extracted from the liner. This sampling tool is most often used for soil profiling and collection of larger volume soil samples (1,300 ml).

The Large Bore Sampler (Figure 2) consists of a 22-inch long by a slightly over 1-inch diameter steel sampling tool and may be used for sampling to depths of approximately 30 feet. Various liner types are available for use with this sampler, and include: plastic, brass, stainless steel, and teflon. The metal liners are available in segmented 6-inch lengths. The sampler is designed for discrete interval sampling and is not affected significantly by borehole wall collapse. This sampler is similar to a piston sampler where a retractable drive (piston) point is withdrawn when the targeted sampling interval is achieved and the soil sample enters the sampler. Once the sampler is removed from the ground, the inserted liner containing the soil sample is extracted from the sampler and the soil sample is then cut from or extracted from the liner. The segmented liner materials and discrete interval sampling capability gives this device greater suitability for collection of smaller volume soil samples (320 ml).

1.3 Quality Assurance Planning Considerations

Sampling personnel should follow specific quality assurance guidelines as outlined in the site-specific Quality Assurance Project Plan (QAPP). Proper quality assurance requirements should be provided which will allow for collection of representative samples from representative sampling points. Quality assurance requirements outlined in the QAPP typically suggest the collection of a sufficient quantity of field duplicate, field blank, and other samples.

1.4 Health and Safety Considerations

The health and safety considerations for the site, including both potential physical and chemical hazards, will be addressed in the site-specific Health and Safety Plan (HASP). All field activities will be conducted in conformance to this HASP. In the absence of a site-specific HASP, work will be conducted according to the ENSR Health and Safety Policy and Procedures Manual and/or direction from the Regional Health and Safety Manager.

2.0 RESPONSIBILITIES

2.1 Project Geologist/Engineer

It will be the responsibility of the project geologist/sampling engineer to conduct subsurface soil sampling in a manner which is consistent with this SOP. The project geologist/sampling engineer will observe all activities pertaining to subsurface soil sampling to ensure that the SOP is followed, and to record all pertinent data onto a boring log. It is also the project geologist/sampling engineer's responsibility to indicate the specific targeted sampling depth or sampling interval to the drilling subcontractor. The project geologist/sampling engineer is also responsible for the collection of representative environmental or stratigraphic characterization samples once the sampling device has been retrieved and opened. Additional sample collection responsibilities include labeling, handling, and storage of samples until further chain-of-custody procedures are implemented.

2.2 Drilling Subcontractor

It will be the responsibility of the drilling subcontractor to provide the necessary Geoprobe™ equipment for obtaining subsurface soil samples. This generally includes the truck or ATV-mounted percussion/probing machine and one or more Macro-Core and Large Bore samplers in good operating condition, appropriate liners, and other necessary equipment for borehole preparation and sampling. It is the drilling subcontractor's responsibility to provide and maintain their own boring logs if desired. Equipment decontamination materials should also be provided by the subcontractor and should meet project specifications.

3.0 REQUIRED MATERIALS

In addition to those materials provided by the subcontractor, the project geologist/sampling engineer will require:

- Project Sampling Plan, QAPP, and HASP
- Boring Logs
- Teaspoon or spatula
- Sample kit (bottles, labels, custody records and tape, cooler)
- Sample collection pan
- Folding rule or tape measure
- Utility knife
- Equipment decontamination materials (as required by QAPP)
- Health and safety equipment (as required by HASP)
- Field project notebook/pen

Sampling equipment which comes in direct contact with environmental samples during the sample collection process should be constructed of stainless steel, teflon, or glass, unless specified otherwise in the Project Sampling Plan or QAPP.

4.0 METHOD

4.1 General Method Description

Geoprobe™ soil sampling methods generally involve collection of soil samples by driving the sampling tool directly into the ground using the percussion/probing machine and without the aid of hollow-stem augers or other casing-installed drilling methods. Both the Macro-Core and Large Bore soil samplers consist of metal tubes of seamless construction which can not be split apart like split-spoons. Liner/sleeve inserts are required in order to extract an intact soil core/sample from the sampling device.

Both sampling devices operate by being directly pushed/hammered into the ground by the percussion/probing machine. The borehole is created as the sampling device is advanced downward. The Macro-Core Sampler collects samples continuously and requires that an open borehole be maintained for efficient sample recovery. The Large Bore Sampler contains a piston tip/drive point which allows for advancing the sampler to a designated depth for discrete interval sampling. The piston tip is retracted when the desired sampling interval is reached.

When the soil sampling device is retrieved from the borehole, the drive head, cutting shoe and/or piston assembly is removed, and the liner insert with sample is removed from the sampling device. The project geologist/sampling engineer is then given access to the sample for whatever purpose is required.

Table 1 summarizes the construction characteristics and sampling attributes of each type of sampler. The appropriate type of sampler should be selected based on project-specific sampling requirements.

4.2 Equipment Decontamination

Each sampling device must be decontaminated prior to its initial use and following collection of each soil sample, especially if sampling for analytical testing purposes is conducted. If sampling for soil logging only is conducted, thorough sampler decontamination between samples may not be necessary although sufficient cleansing is necessary for the sampler to operate properly. Site-specific requirements for equipment decontamination should be outlined in the Project Sampling Plan. Equipment decontamination procedures are also outlined within SOP 7600 - Decontamination of Equipment.

4.3 Sampling Procedures - Macro-Core Sampler

(Note: These procedures are excerpted from Geoprobe™ Systems literature. This SOP assumes that the subcontractor will perform sampling; therefore, detailed procedures regarding sample aquisition are not provided.)

4.3.1 Sampler Preparation

- Decontaminate the sampler parts (cutting shoe, sample tube, liners) before assembly.
- Assemble the sampler by first placing the liner over the inside end of the cutting shoe, then inserting the liner/shoe assembly into the sample tube, and then finally threading the cutting shoe into the sample tube. Tighten the cutting shoe with the shoe wrench.
- Thread the sampler onto the drive head.

4.3.2 Sampling

- Using the percussion/probing machine, drive the sampler into the ground until the drive head reaches the ground surface.
- For deeper samples, the borehole walls must remain stable. The cutting shoe is designed with a tapered surface to limit sidewall scraping. Add additional probe rods until the sampler reaches the

targeted sample interval, then drive the sampler through the desired sample interval.

- Use the machine hydraulics to pull the sampler from the borehole.

4.3.3 Sample Recovery

- Once the sampler has been removed from the borehole, the sampler must be unthreaded from the drive head, the cutting shoe unthreaded from the sampler, and the liner/shoe assembly removed from the sample tube.

- Disconnect the cutting shoe from the liner which contains the soil sample. The recovered soil sample may now be viewed, logged, and extracted from the liner for analysis (refer to Section 4.5 for sample containment procedures).

4.4 Sampling Procedures - Large Bore Sampler

(Note: These procedures are excerpted from Geoprobe™ Systems literature. This SOP assumes that the subcontractor will perform sampling; therefore, detailed procedures regarding sample aquisition are not provided. Additional detailed sampling procedures for this specific item of equipment is presented in Geoprobe™ Technical Bulletin No.93-660, appended to this SOP.)

4.4.1 Sampler Preparation

- Decontaminate the sampler parts (cutting shoe, piston rod/tip, sample tube, liners) before assembly.

- Assemble the sampler by first placing the liner on the cutting shoe, then threading the liner/shoe assembly into the sample tube, then connecting the piston tip to the piston rod, and then finally inserting the piston tip/rod assembly into the sample tube. Tighten the cutting shoe with the shoe wrench.

- Thread the sampler onto the drive head. Thread the stop-pin onto the drive head (stop-pin holds the piston tip/rod in place while driving the sampler to the desired sample interval).

4.4.2 Sampling

- Using the percussion/probing machine, drive the sampler into the ground until the upper portion of the targeted sampling interval is achieved.

- Unthread and remove the stop-pin from the drive head using extension rods. This will activate the piston tip/rod.

- Drive the sampler through the targeted sampling interval to collect the sample. The piston tip/rod will retract as the sample enters the sample tube.

- Use the machine hydraulics to pull the sampler from the ground.

4.4.3 Sample Recovery

- Once the sampler has been removed from the ground, the sampler must be unthreaded from the drive head, then the cutting shoe unthreaded from the sample tube, and the liner/shoe assembly removed from the sample tube.

- Disconnect the cutting shoe from the liner which contains the soil sample. The recovered soil sample may now be viewed, logged, and extracted from the liner for analysis (refer to Section 4.5 for sample containment procedures).

4.5 Sample Containment

4.5.1 General

- The soil sample can be removed from the liner following viewing and/or logging. Non-segmented plastic or teflon liners should be cut with a utility knife into approximate 6-inch lengths to facilitate sample extraction or to isolate specific sample zones targeted for analysis. Segmented metal liners can be manually separated.

- Once the liner has been separated, the soil sample may be extracted from the individual liner segments with a spoon or spatula. Except for volatile organic samples (see below), the soil sample should be placed into a sample collection pan and homogenized. Place the sample directly into the required sample container.

- Once filled, the sample container should be properly capped, cleaned and labeled. Sample chain-of-custody and preservation procedures should then be initiated.

- Perform equipment decontamination following containment of the sample.

4.5.2 Volatile Organic Samples

- Use of teflon liners is preferred when sampling for analysis of volatile organic compounds (VOC) because these liners are more inert. In order to limit the potential for loss of volatiles, the soil sample should be removed from the liner as soon as possible after sample recovery. VOC soil samples should be selected from a central point within the liner unless another specific sample zone has been targeted. The liner should be cut with a knife and the sample immediately extracted and containerized. Clean and label the container and place it into a cooler immediately. Residual sample may then be used to fill other sample or logging requirements.

5.0 QUALITY CONTROL

Quality control requirements are dependent on project-specific sampling objectives. The QAPP will provide requirements for equipment decontamination (frequency and materials), sample preservation and holding times, sample container types, sample packaging and shipment, as well as requirements for the collection of various quality assurance samples such as trip blanks, field blanks, equipment blanks, and field duplicate samples.

6.0 DOCUMENTATION

Various forms are required to ensure that adequate documentation is made of sample collection activities. These forms include:

- Boring logs
- Field log books
- Sample collection records
- Chain-of-custody records
- Shipping labels

Boring logs (Figure 3) will provide visual and descriptive information for each sample collected and are often the most critical form of documentation generated during a soil sampling program. The field log book is kept as a general log of activities and should not be used in place of the boring log. Occasionally, sample collection records are used to supplement boring logs, especially for environmental samples which have been collected for laboratory analysis. Chain-of-custody forms are transmitted with the samples to the laboratory for sample tracking purposes. Shipping labels are required if sample coolers are to be transported to the laboratory by a third party (courier service). Original copies of these records should be maintained in the appropriate project files.

7.0 REFERENCES

Geoprobe™ Systems, August 1993, "1993-94 Equipment and Tools Catalog".

TABLE 1
Geoprobe Systems Soil Sampler Characteristics

Sampler Type	Length (in.)	Diameter (in.)	Volume (ml)	Sleeve Liner Type	Suitability[1]			
					Soil Logging	Physical Testing	Chemical-Inorganics	Chemical-Organics
Macro-Core	45	1.5	1,300	Acetate Stainless Steel Teflon	A B A	A A A	A B A	B A A
Large Bore	22	1.06	320	Acetate Brass Stainless Steel Teflon	A B B A	A A A A	A B B A	B B A A

[1] **A - Preferred suitability**
B - Acceptable suitability

Figure 1 – Soil Sampling Tools – Macro-Core Sampler - Parts

SOIL SAMPLING TOOLS - Macro-Core Sampler - Parts

Macro-Core Sampler

AT-720 Series

The sampler features a nickel-plated sample tube that is 48" long x 2.0" in diameter, a hardened tool steel cutting shoe that has a 1.5" diameter opening, and a tapered drive head that fits standard Geoprobe probe rods. The overall length assembled is 51.25". Sample recovery is 45" long x 1.50" diameter (1302 ml) in a PETG liner.

PARTS

AT-720	MC Cutting Shoe
AT-721	MC Drive Head
AT-722	MC Sample Tube
AT-725	MC PETG (clear plastic) Liner
AT-726	MC Vinyl End Cap
AT-727	MC Shoe Wrench

KITS

Assembled Macro-Core Sampler*
Part No. AT-720K
Includes the following parts:
(1) **AT-720** MC Cutting Shoe
(1) **AT-721** MC Drive Head
(1) **AT-722** MC Sample Tube
*kit does not include liners and end caps

LINERS

AT-725K	MC PETG Liners (pre-flared, clear plastic) Box of 66 only
AT-726K	MC Vinyl End Caps (fit AT-725 liners) Box of 66 pairs (66 red/66 black)

Macro-Core Parts

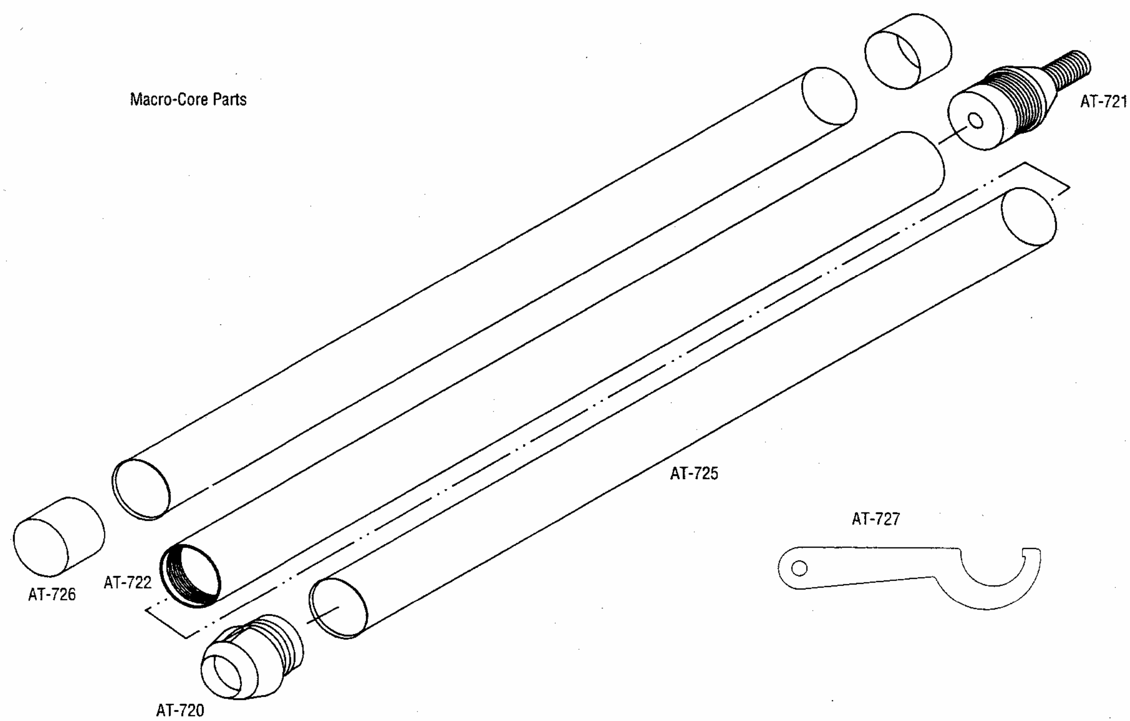


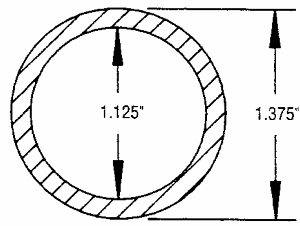
Figure 2 – Soil Sampling Tools – Probe Drive System/Large Bore

SOIL SAMPLING TOOLS - Probe Drive System/Large Bore

Large Bore Sampler

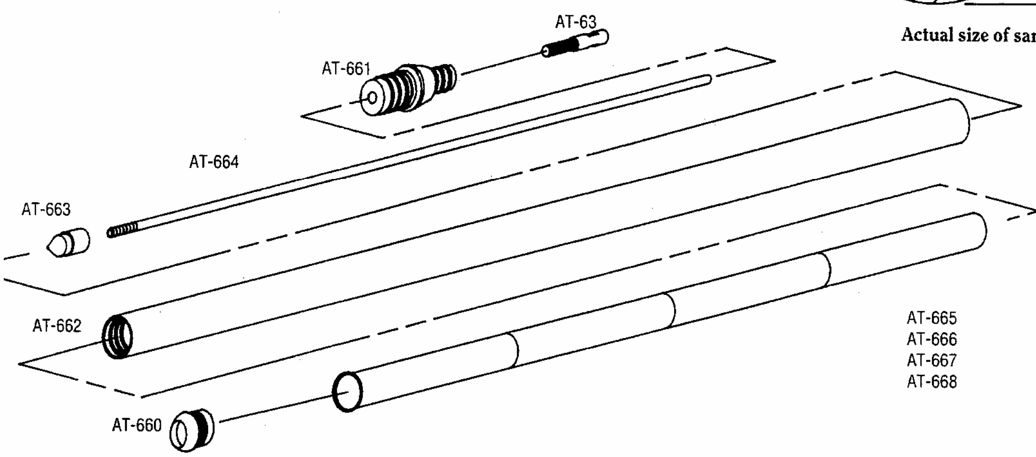
AT-660 Series

Features nickel plated sample tube, replaceable hardened tool steel cutting shoe and removable liner. Recovers core approximately 22" long x 1-1/16" diameter (320 ml). Uses STD Piston Stop-Pin. Recommended for sampling depths up to 30 feet. Liners available in brass, stainless steel, PTFE (Teflon), or PETG (clear plastic).



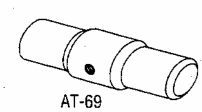
Actual size of sample tube

Large Bore Sampler Parts:



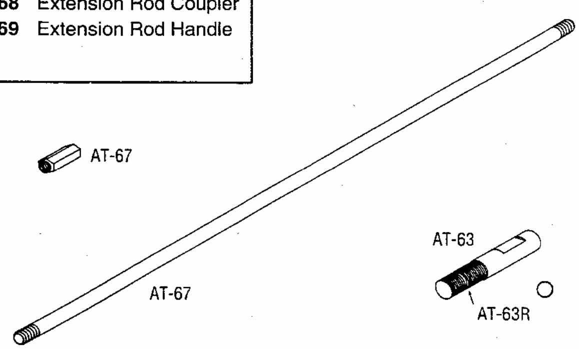
PARTS

Large Bore Sampler Parts	Liners	Also required:
AT-660 LB Cutting Shoe	**AT-665** LB PETG Liner	**AT-63** STD Stop-Pin
AT-661 LB Drive Head	**AT-666** LB Brass Liner	**AT-63R** Stop-Pin O-rings
AT-662 LB Sample Tube	**AT-667** LB Stainless Liner	**AT-67** Extension Rod
AT-663 LB Piston Tip	**AT-668** LB PTFE Liner	**AT-68** Extension Rod Coupler
AT-664 LB Piston Rod		**AT-69** Extension Rod Handle
AT-669 LB Shoe Wrench		



PARTS

Parts used with all Probe-Drive Samplers	
AT-63	STD Stop-Pin
AT-63R	Stop-Pin O-rings
AT-67	Extension Rod
AT-68	Extension Rod Coupler
AT-69	Extension Rod Handle



Extension Rod Parts

Stop-Pin Parts

Geoprobe Systems

Figure 3 – Boring Log

BORING LOG

Sheet 1 of

Project No. ______ Date - Start ______ Finish ______ Boring ______

Project Name ______ Drilling Co. ______

Location ______ Drilling Method ______

Total Depth ______ Inspector ______ Reviewer ______

Remarks ______

Depth Feet	Sample				Graphic Log	Lithologic Description	Equipment Installed
	Type & No.	Blows per 6 In.	Depth Range	Rec.			

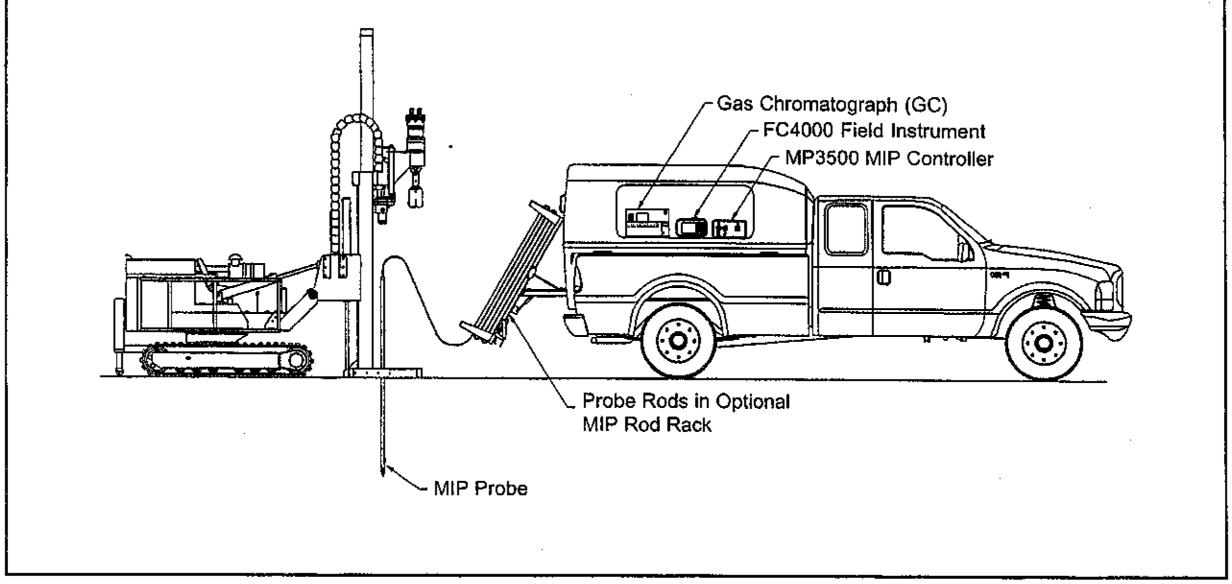
Appendix B
Direct Push Sampling Methods and Procedures

GEOPROBE® MEMBRANE INTERFACE PROBE (MIP)

STANDARD OPERATING PROCEDURE

Technical Bulletin No. MK3010

PREPARED: May, 2003



THE MIP SYSTEM MAY BE DEDICATED TO A SINGLE CARRIER VEHICLE FOR USE IN TANDEM WITH MULTIPLE GEOPROBE® DIRECT PUSH MACHINE MODELS

Geoprobe Systems®

A DIVISION OF KEJR, INC.

Geoprobe Systems®

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are Registered Trademarks of Kejr, Inc., Salina, Kansas**

Equipment and tool specifications, including weights, dimensions, materials, and operating specifications included in this brochure are subject to change without notice. Where specifications are critical to your application, please consult Geoprobe Systems®.

1.0 OBJECTIVE

This document serves as the standard operating procedure for use of the Geoprobe Systems® Membrane Interface Probe (MIP) to detect volatile organic compounds (VOCs) at depth in the subsurface.

2.0 BACKGROUND

2.1 Definitions

Geoprobe®: A brand name of high quality, hydraulically-powered machines that utilize both static force and percussion to advance sampling and logging tools into the subsurface. The Geoprobe® brand name refers to both machines and tools manufactured by Geoprobe Systems®, Salina, Kansas. Geoprobe® tools are used to perform soil core and soil gas sampling, groundwater sampling and testing, soil conductivity and contaminant logging, grouting, and materials injection.
**Geoprobe® is a registered trademark of Kejr, Inc., Salina, Kansas.*

Membrane Interface Probe (MIP): A system manufactured by Geoprobe Systems® for the detection and measurement of volatile organic compounds (VOCs) in the subsurface. A heated probe carrying a permeable membrane is advanced to depth in the soil. VOCs in the subsurface cross the membrane, enter into a carrier gas stream, and are swept to gas phase detectors at ground surface for measurement.

2.2 Discussion

The MIP is an interface between contaminates in the soil and the detectors at ground surface. It is a screening tool used to find the depth at which the contamination is located, but is not used to determine concentration of the compound. Two advantages of using the MIP are that it detects contamination in situ and can be used in all types of soil conditions.

Refer to Figure 2.1. The MIP is a logging tool used to make continuous measurements of VOCs in soil. Volatile compounds outside the probe diffuse across a membrane and are swept from the probe to a gas phase detector at ground surface. A log is made of detector response with probe depth. In order to speed diffusion, the probe membrane is heated to approximately 100° C (212° F).

Along with the detection of VOCs in the soil, the MIP also measures the electrical conductivity of the soil to give a probable lithology of the subsurface. This is accomplished by using a dipole measurement arrangement at the end of the MIP probe so that both conductivity and detector readings may be taken simultaneously. A simultaneous log of soil conductivity is recorded with the detector response.

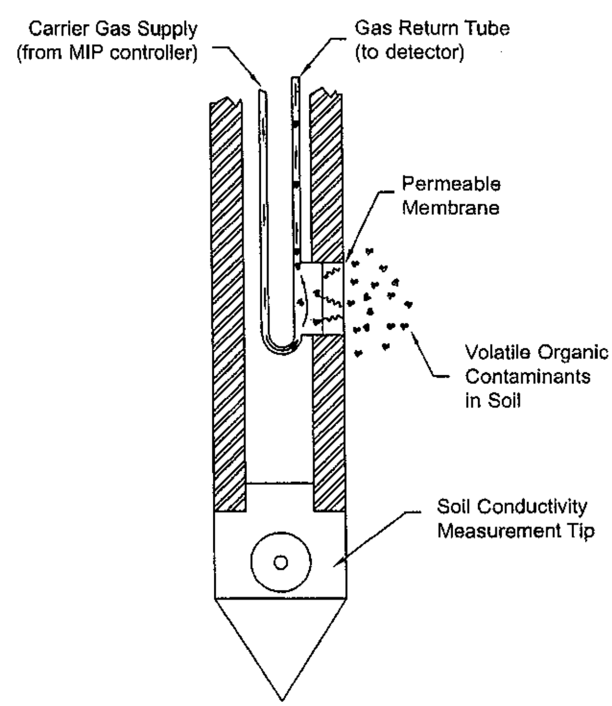

Figure 2.1
Schematic drawing of the MIP probe

3.0 Tools and Equipment

The following equipment is needed to perform and record an MIP log. Basic MIP system components are listed in this section and illustrated in Figure 3.1. Refer also to Appendix I for more required tools as determined by your specific model of Geoprobe® direct push machine.

3.1 Basic MIP System Components

Description	Quantity	Part Number
Field Instrument	(1)	FC4000
MIP Controller	(1)	MP3500
MIP/EC Acquisition Software	(1)	MP3517
MIP Probe	(1)	MP4510
Replacement Membrane	(1)	MP3512
Membrane Wrench	(1)	16172
LB Sample Tube	(1)	AT6621
Stringpot (linear position transducer)	(1)	SC160
Stringpot Cordset	(1)	SC161
MIP O-ring and Service Kit	(1)	MP2515
MIP Trunkline, 100-ft (30 m) length	(1)	MP2550
Extension Cord, 25-ft (8 m) length	(1)	SC153
Needle Valve	(1)	13700
24-in. Nafion Dryer Tube	(1)	12457

3.2 Anchoring Equipment

Description	Quantity	Part Number
Soil Anchor, 4.0-in. OD flight	(3)	10245
Anchor Foot Bridge	(1)	10824
Anchor Plate	(3)	10167
GH60 Hex Adapter (if applicable)	(1)	10809
Chain Vise	(3)	10075

3.3 Optional Accessories

Description	Quantity	Part Number
MIP Trunkline, 150-ft (46 m) length	(1)	13999
MIP Trunkline, 200-ft (61 m) length	(1)	15698
FID Compressed Air System	(1)	AT1004
Hydrogen Gas Regulator	(1)	10344
Nitrogen Gas Regulator	(1)	13940
Cable Rod Rack, for 48-in. rods	(1)	18355
Rod Cart Assembly, for 1.25-in. OD rods	(1)	SC610
Rod Cart Hitch Rack, for SC610	(1)	SC650K
Rod Cart Carrier, for SC610	(1)	SC675
Rod Wiper, for 5400 Series foot	(1)	AT1255
Rod Wiper, for 66 Series foot	(1)	18181
Rod Grip Pull Handle, for GH40 hammer	(1)	GH1255
Rod Grip Pull Handle, for GH60 hammer	(1)	9641
Water Transport System	(1)	19011

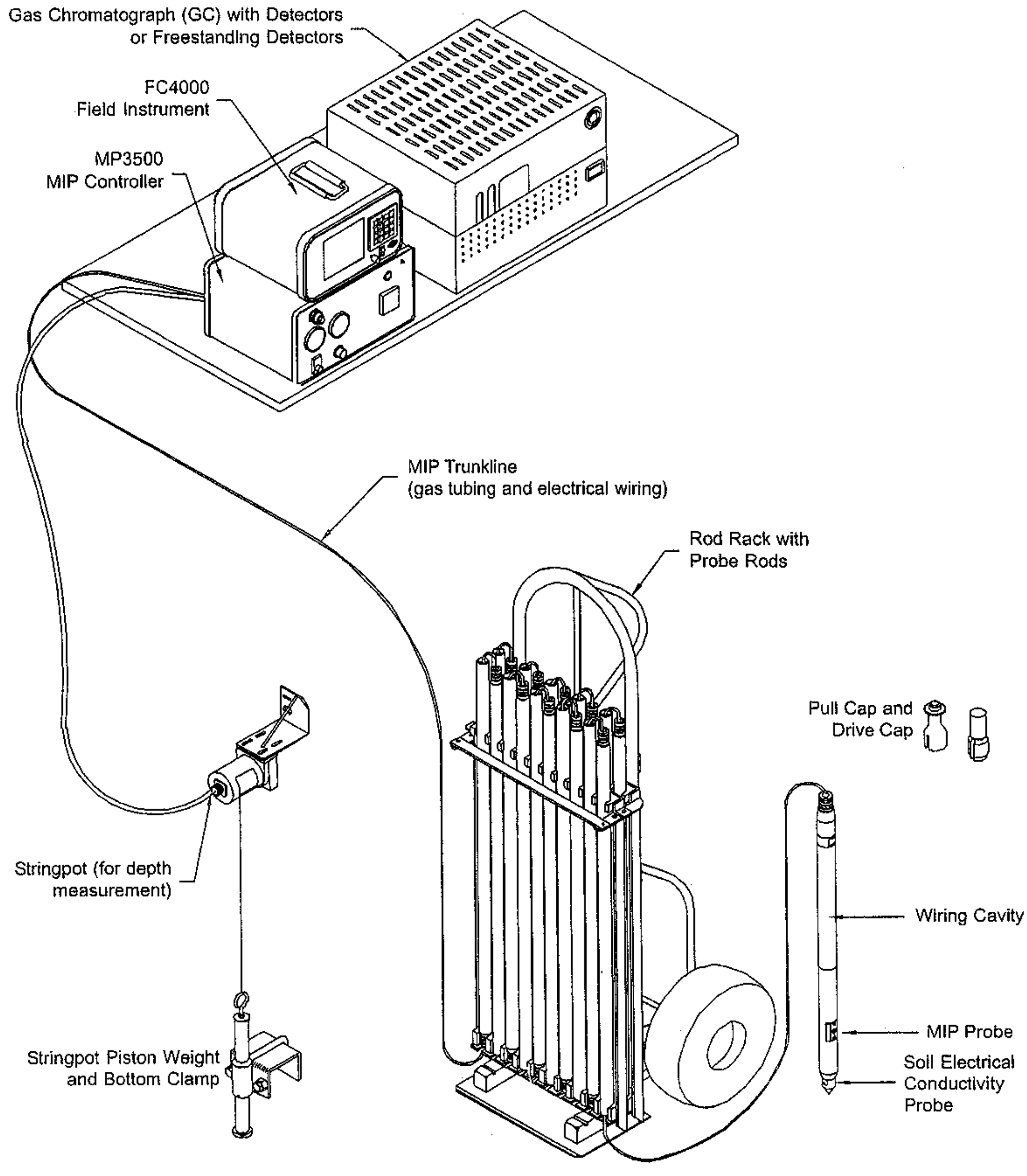

Figure 3.1
MIP system components

4.0: Quality Control - Response Testing

Response testing is an important quality control measure used to validate each log by proving that the integrity of the system is intact. Without running a response test, the operator will not know if the system is detecting the correct compounds or even if the system is working.

4.1 Preparation for Response Testing

Response testing is a necessary part of the MIP logging process because it ensures that the entire system is working correctly and also enables the operator to measure the trip time. Trip time is the time it takes for the contaminant to go from the probe, through the trunk line, and to the detectors. This time will need to be entered into the MIP software for depth calculations as described later in this document.

The following items are required to perform response testing:

- Neat sample of the analyte of interest (i.e.: benzene, TCE, PCE, etc.) purchased from chemical vendor
- Microliter syringes
- 25- or 50-mL Graduated cylinder
- Several 40-mL VOC vials with labels
- Testing cylinder made from a nominal 2-in. PVC pipe with a length of 24 in.
- 0.5 L plastic beaker or pitcher
- 25 mL Methanol
- Supply of fresh water, 0.5 L needed per test
- 5-gallon bucket filled with fine sand and water
- Stopwatch

Preparation of the stock standard is critical to the final outcome of the concentration to be placed into the testing cylinder.

1. Pour methanol into graduated cylinder to the 25 mL mark.

2. Pour 25 mL of methanol from graduated cylinder into 40-mL VOC vial.

3. Mix appropriate volume of desired neat analyte into 40-mL VOC vial containing 25 mL of methanol. The required volume of neat analyte for five common compounds is listed in Column 3 of Table 4.1. Use the equation at the then of this section to calculate the appropriate neat analyte volume for other compounds of interest.

4. Label the vial with name of standard (i.e. TCE, PCE, Benzene), concentration (50 mg/mL), date created, and created by (your name). This is the Stock Standard.

The equation used for making a stock standard is shown on the following page.

Table 4.1
Density and required volumes of neat compounds used to make a 50 mg/mL working standard into 25 ml of methanol

Compound	Density (mg/uL)	Volume of Neat Analyte Required to Prepare a Working Standard (uL)
Benzene	0.8765	1426
Toluene	0.8669	1442
Carbon Tetrachloride	1.594	784
PCE	1.6227	770
TCE	1.4642	854

25 mL (methanol) x 50 mg/mL = 1250 mg
1250 mg x 1/density of analyte = amount of neat material to be placed into 25 mL of Methanol

Example: Preparation of 50 mg/mL Benzene standard.
1250 mg x 1/0.8765 mg/uL = 1426 uL
Use 1426 uL of neat Benzene in 25 mL of Methanol to get a 50 mg/mL standard.

4.2 Response Test Procedure

With the standard prepared, the operator is ready to test the response of the probe as described below.

1. Immerse the probe into the 5-gallon bucket of fine sand and water to stabilize the baseline. This is necessary due to the sensitivity of the photoionization detector (PID) and the electron capture detector (ECD) to water.

2. Access the MIP Time software and view the detector vs. time data. The detector signals should be stable before proceeding.

3. Obtain 500 mL of water (either tap water or distilled) in a suitable measuring container.

Table 4.2
Volume of 50 mg/mL working standard and final concentration in 0.5 L test sample volume

Volume of 50 mg/mL Standard	Final Concentration of 0.5 L Sample (mg/L or ppm)
1000 uL	100
100 uL	10
10 uL	1

4. Use a standard volume specified in Table 4.2 to mix the desired test concentration. This is the Working Standard.

5. Pour the working standard into a nominal 2-inch x 24-inch PVC pipe and immediately insert the MIP into the solution (Fig. 4.1). Leave the probe in the test solution for 45 seconds. At the end of 45 seconds, place the probe back in the 5-gallon bucket of sand and water.

6. From the results on the MIP Time software the trip time and response time can both be measured (Fig. 4.2).

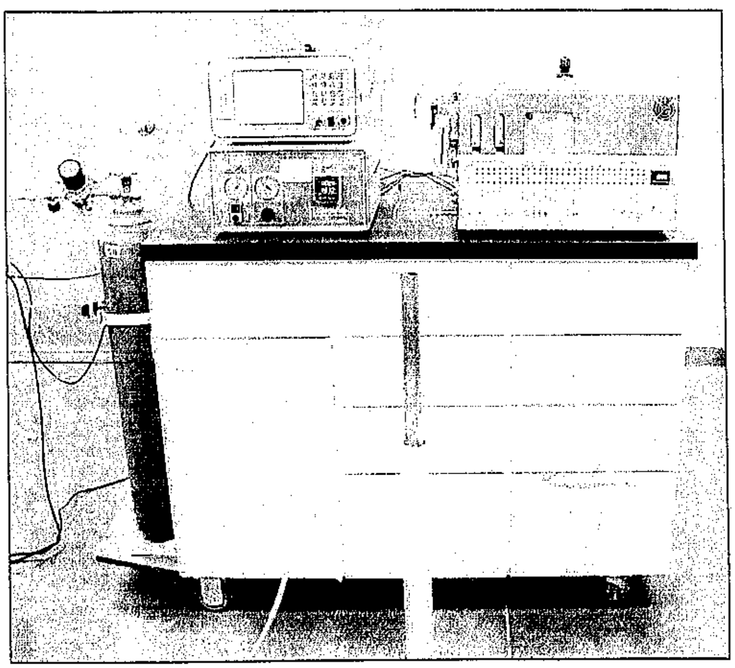

Figure 4.1
The MIP probe is placed in a PVC pipe containing the standard solution.

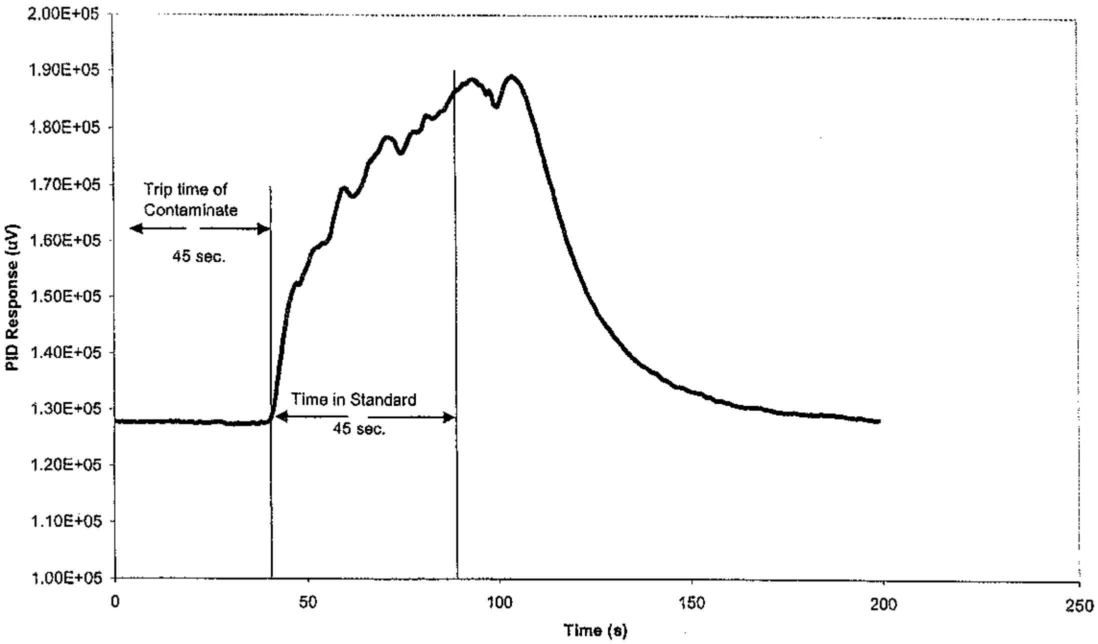

Figure 4.2
SRI PID Response Test - 10 ppm Benzene

5.0 Field Operation

1. Power on the generator.
2. Turn on any gases that will be used for the MIP system (i.e. nitrogen carrier gas, hydrogen for the FID, etc.). Check the flow rate of the system and psi on the mass flow controller. Compare these numbers to previous work.
3. Power on the detector or detectors and allow to warm up to set temperature (approximately 30 minutes).
4. Power on the MP2500 or MP3500 MIP Controller.
5. Power on the computer or the FC4000 Field Instrument.
6. Advance a pre-probe 3 to 4 feet into the subsurface at the location to be logged.
7. Remove the pre-probe and raise the probe foot of the direct push machine.
8. If advancing the MIP with percussion, raise the probe foot enough to slide the rod wiper plate underneath.
9. If pushing only, turn the desired amount of anchors into the subsurface and return the probe foot to the position from which the pre-probe was advanced. Leave the probe foot raised sufficiently to allow sliding the rod wiper underneath.
10. Place the rod wiper plate under the foot such that the opening is directly over the pre-probed hole. Lower the foot firmly onto the rod wiper.

11. If pushing only, position the anchoring bridge over the foot of the machine such that the anchors extend through the holes in the bridge (fig. 5.1). Install a chain vise at each anchor to secure the bridge.

12. With the software loaded, run a response test (Section 4.0) and record the height of the peak response and the trip time into a field notebook. Refer to Figure 4.2.

13. If the trip time is different than what was placed into the software, restart the software and enter the correct trip time.

14. Attach a slotted drive cap to the MIP drive head.

15. Insert the MIP point into rod wiper opening and drive it into the soil until the membrane of the probe is at ground level.

16. Connect the stringpot cable to the stringpot weight located on the probe foot and pull keeper pin so the weight drops to the ground.

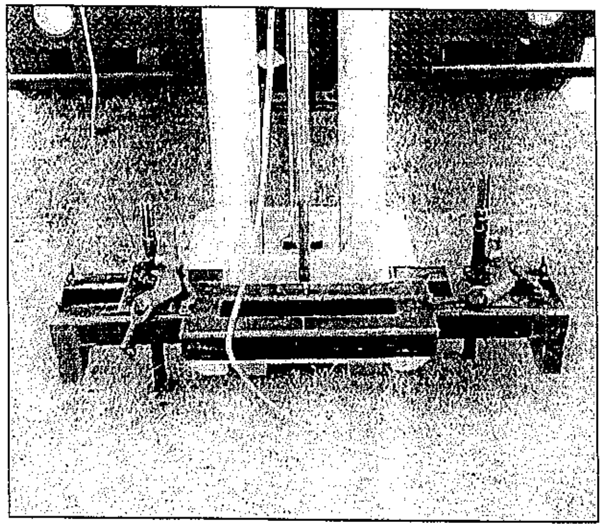

Figure 5.1
Anchor the probe foot to allow advancement of MIP probe by push only (no percussion).

NOTE: **Do not allow the stringpot cable to retract into the stringpot housing at a high rate. This will ultimately damage the stringpot.**

17. Record the system parameters in a field notebook at this time (i.e.. mass flow, trip time).

NOTE: **If the mass flow reading drops or rises more than one psi, turn off the flow at the primary controller and remove the probe from the ground. If the temperature monitor quits heating or gives an error, remove the probe from the ground.**

18. Place the trigger switch in the "ON" position.

19. Advance the probe at a rate of 1 ft/min to the predetermined log depth or until refusal is attained.

NOTE: **Refusal is attained when it takes longer than 1.5 minutes of continuous hammering to advance the probe one foot. This is the maximum time to reach one foot of probe travel.**

20. When the MIP log is complete, turn the trigger off and slowly return the stringpot cable into the stringpot housing.

21. Pull the probe rod string using either the Geoprobe® rod grip pull system or a slotted pull cap.

22. When the MIP reaches the surface, clean the face with water and run a response test. This response test should be written down in the field notes and compared to the initial test. This system check ensures the data for that log is valid.

23. Save the data to a 3.5-inch floppy disk and exit the MIP software.

24. Data from the MIP can now be graphed with Direct Image® MIP Display Log or imported into any spreadsheet for graphing.

6.0 Replacing a Membrane on the MIP Probe

A probe membrane is considered in good working condition as long as two requirements are met: 1) The butane sanity test result is greater than 1.0E+06 uV response, 2) Flow of the system has not varied more than 3 mL/min from the original flow of the system (a flow meter or bubble flow meter should be kept with the system at all times). If either one of these requirements are not met, a new face must be installed as follows.

1. Turn the heater off and allow the block to cool to less than 50° C on the control panel readout.

2. Clean the entire heating block with water and a clean rag to remove any debris.

3. Dry the block completely before proceeding.

4. Remove the membrane using the membrane wrench (Fig. 6.1). Keep the wrench parallel to the probe while removing the membrane to ensure proper engagement with socket head cap screw.

NOTE: Do <u>Not</u> leave the membrane cavity open for extended periods. Debris can become lodged in the gas openings in the plug.

5. Remove and discard the copper washer as shown in Figure 6.2. Each new membrane is accompanied by a new copper washer. **Do not reuse the copper washer.**

6. Inspect the open cavity for any foreign objects. Remove any objects present and clean the inside of cavity of any soil that was deposited on the wall of the block.

7. Insert the new copper washer around the brass plug making sure that it sits flat on the surface of the block.

8. Install the new membrane by threading it into the socket. Use the membrane wrench to tighten the membrane to a snug fit. Do not overtighten.

9. Turn the gas on and leave the heater off. Apply water to the membrane and surrounding area to check for leaks. If a leak is detected (bubbles are formed in the water), use the membrane wrench to further tighten the membrane.

10. Use a flow meter/bubble flow meter to check flow to the detectors. Record this value in a field notebook.

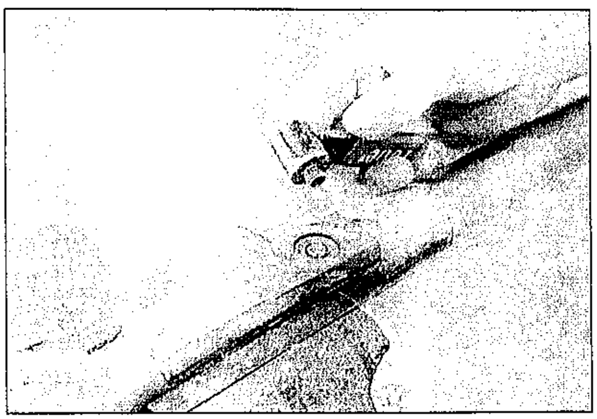

Figure 6.1
Unthread the membrane from the probe block.

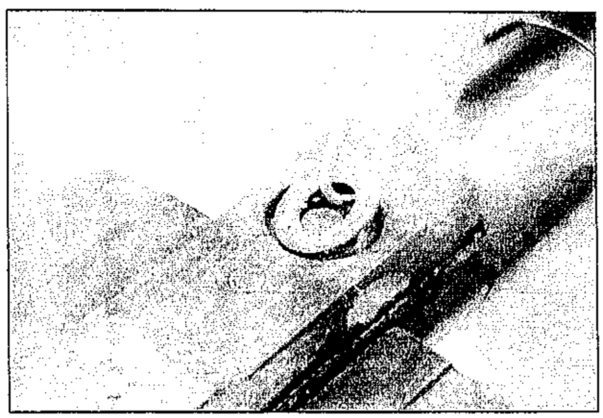

Figure 6.2
Remove and discard the copper washer.

Appendix I: Tools for Various Direct Push Machines

Model 5400 and 54DT Direct Push Machines

Description	*Part Number*
Stringpot Mounting Bracket	SC110
Stringpot Bottom Clamp	SC111
Stringpot Piston Weight	SC112
Slotted Drive Cap, for 1.25-in. rods	AT1202
Slotted Pull Cap, for 1.25-in. rods	AT1203
MIP Drive Adapter, for 1.25-in. rods	MP2512
MIP Drive Head	GW1516
Probe Rod, 1.25-in. x 48-in.	AT1248

Model 54LT Direct Push Machine

Description	*Part Number*
Stringpot Mounting Bracket	11433
Stringpot Bottom Clamp	SC111
Stringpot Piston Weight	SC112
Slotted Drive Cap, for 1.25-in. rods	AT1202
Slotted Pull Cap, for 1.25-in. rods	AT1203
MIP Drive Adapter, for 1.25-in. rods	MP2512
MIP Drive Head	GW1516
Probe Rod, 1.25-in. x 48-in.	AT1248

Model 5410 Direct Push Machine

Description	*Part Number*
Stringpot Piston Weight	SC112
Slotted Drive Cap, for 1.25-in. rods	AT1202
Slotted Pull Cap, for 1.25-in. rods	AT1203
MIP Drive Adapter, for 1.25-in. rods	MP2512
MIP Drive Head	GW1516
Probe Rod, 1.25-in. x 48-in.	AT1248

Model 6600, 66DT and 6610DT Direct Push Machines

Description	*Part Number*
Stringpot Mounting Bracket	16971
Stringpot Bottom Clamp	11751
Stringpot Piston Weight	SC112
Slotted Drive Cap, for 1.5-in. rods	15607
Slotted Pull Cap, for 1.5-in. rods	15164
Drive Cap Adapter, for GH60 and 1.25-in. rods	15498
MIP Drive Adapter, for 1.5-in. rods	18563
MIP Friction Reducer	18564
Probe Rod, 1.5-in. x 48-in.	13359

Geoprobe Systems®

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1-800-436-7762 • Fax 785-825-2097
www.geoprobe.com

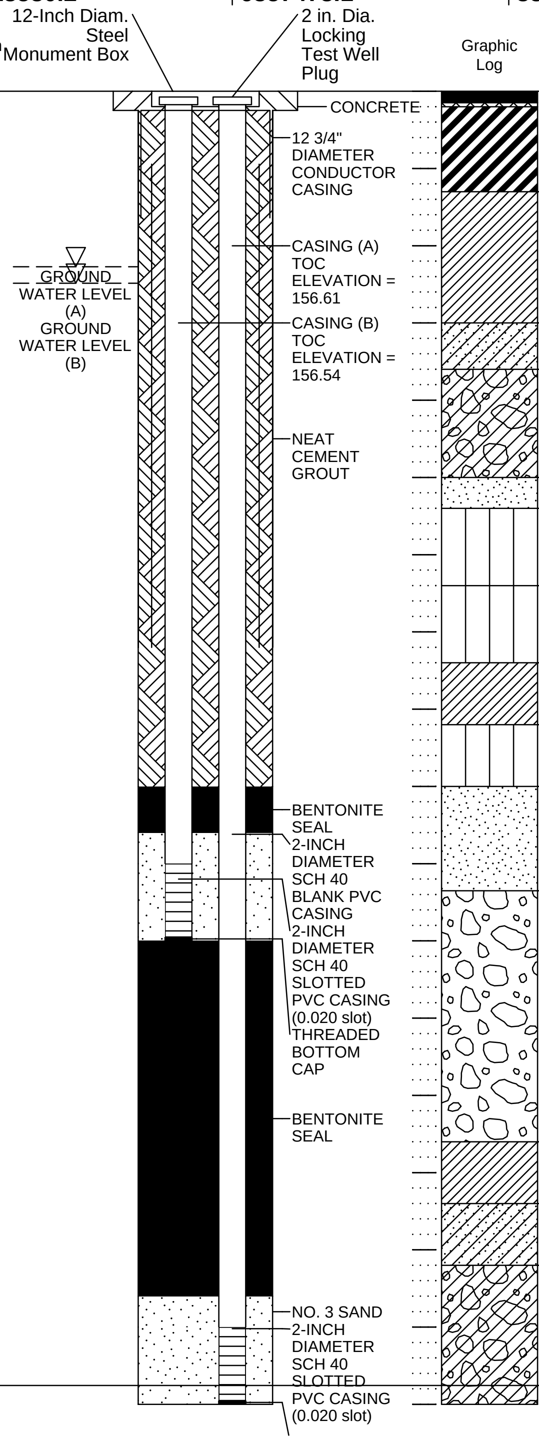
Appendix C
Boring Logs

WELL CONSTRUCTION LOG

ENSR INTERNATIONAL

ENSR Corporation, Inc.
10411 Old Placerville Road
Suite 210
Rancho Cordova, Ca. 95827
916-362-7100
www.ensr.com

BOREHOLE NUMBER	MW-12A/B
PROJECT NAME	Unocal No 2672
PROJECT NUMBER	06940-268-120
LOCATION	1075 Santa Rosa Avenue, Santa Rosa, California
DRILLING CONTRACTOR / DRILLER	Gregg Drilling & Testing / Robert / Trevor
LOGGED BY	Will Speth
DRILLING EQUIPMENT / METHOD	BK-61&BK-53 / Mud-Rotary&HSA
BIT SIZE / BIT TYPE	15-inch / Auger
SAMPLING METHOD	SS 2 in. O.D.
START-FINISH DATE	4/27/04 - 5/5/04
CASING MATL. / DIAMETER	Sch. 40 PVC/2 in.
SCREEN: TYPE	Slotted
MATL.	PVC
TOTAL LENGTH	15
DIA.	2 in.
SLOT SIZE	0.020
ELEVATION OF: (FT.) GROUND SURFACE	156.90
TOP OF WELL CASING	
TOP & BOTTOM SCREEN	106.90 / 71.90
GW SURFACE	
DATE	
NORTHING	1918530.2
EASTING	6357478.1
LATITUDE	38.4281079
LONGITUDE	-122.7127705
DATUM	MSL



Depth (feet)	Visual Description	Blow Counts	Sample ID	OVM Values (ppm)
0	ASPHALT SURFACE 3-inches thick			
	FAT CLAY: Black-brown, root structures, medium to hight plasticity, moist, stiff. (CH)			
7	CLAY WITH SILT: Medium brown, medium plasticity, moist, stiff. (CL)	4 8 9	MW-12-10	0
		4 6 20	MW-12-15	0
15	CLAYEY SAND: medium brown, skip-graded sand fine and coarse grained, saturated, dense. (SC)			
18	CLAYEY GRAVEL WITH SAND: Medium brown, coarse grained sand, subangular to subrounded gravel 3/8 to 1 1//2" diameter. wet, very dense. (GC)	15 26 36	MW-12-20	0
25	POORLY GRADED SAND: medium brown coarse grained, saturated. (SP)	12 30 35	MW-12-25	0
27	SANDY SILT: Reddish brown, nonplastic, moist, stiff. (ML)	6 6 7	MW-12-30	0
32	SILT: reddish brown, nonplastic, saturated, hard. (ML)	5 5 8	MW-12-35	0
37	CLAYEY SILT: Tan to dark brown, medium plasticity, moist, hard. (ML)	10 16 19	MW-12-40	0
41	SILT: Tan, nonplastic, saturated, hard. (ML)	12 23 29	MW-12-45	0
45	POORLY GRADED SAND WITH GRAVEL: Reddish-brown, sand medium to coarse grained, gravel subangular to subrounded, 1/4 to 1/2" diameter. saturated, very dense. (SP)	21 50 50-2"	MW-12-50	0
52	POORLY GRADED GRAVEL WITH SAND: Red-oxide stained gravel, reddish-brown, fine and coarse grained sand, skip graded, gravel sub angular to subrounded, 1/4 to 1 1/2" diameter. saturated, very dense. (GP)	20 50-6"	MW-12-55	0
		50-6"	MW-12-60	0
		50-6"	MW-12-65	0
68	SILTY CLAY: medium brown, low plasticity, moist, trace 3/8" diameter subrounded gravel, moist, hard. (CL)	12 35 36	MW-12-70	0
72	CLAYEY SAND: Brown to dark brown, fine to coarse grained sand, trace 3/8" diameter gravel, saturated. (SC)	15 50-6"	MW-12-75	0
76	CLAYEY GRAVEL: medium brown, gravel subangular to subrounded, 1/4 to 1/2" diameter. moist, very dense. (GC)	32 50-6"	MW-12-80	0
85	Bottom of borehole at 85 feet.	15 50-6"	MW-12-85	0

WELL CONSTRUCTION LOG

BOREHOLE NUMBER		
MW-12A/B		
PROJECT NAME **Unocal No 2672**	LOCATION **1075 Santa Rosa Avenue**	
PROJECT NUMBER **06940-268-120**	**Santa Rosa, California**	

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Suite 210
Rancho Cordova, Ca. 95827
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Depth (feet)	(continued)	Graphic Log	Visual Description	Blow Counts	Depth (feet)	Sample ID	OVM Values (ppm)
	THREADED BOTTOM CAP						

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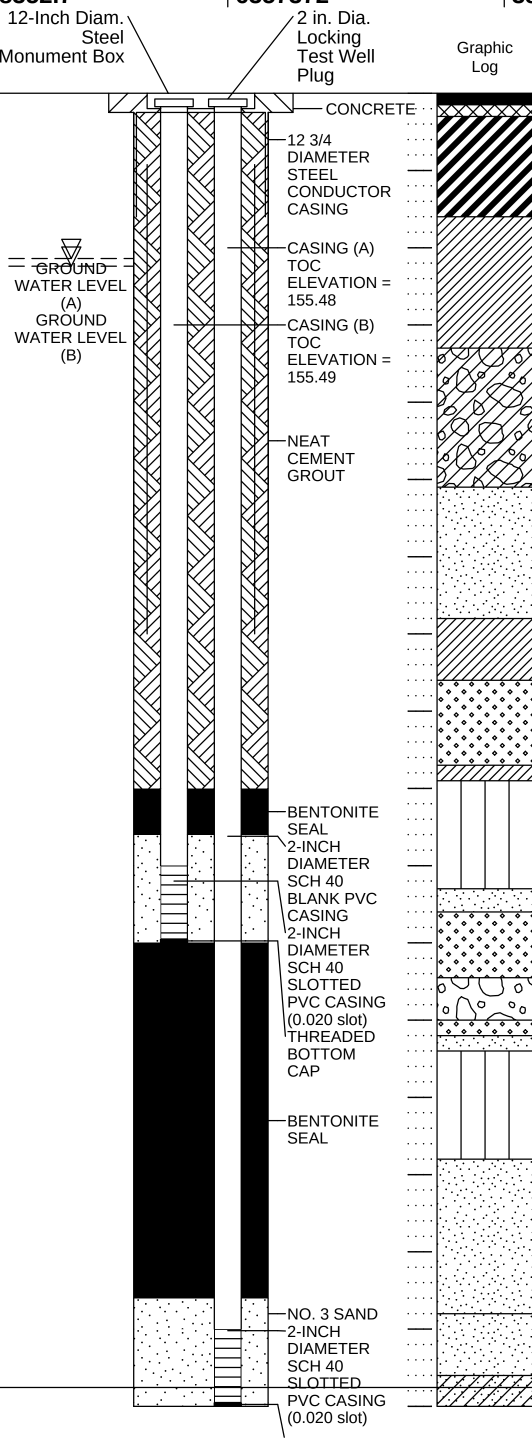
WELL CONSTRUCTION LOG

BOREHOLE NUMBER: **MW-13A/B**			
PROJECT NAME: **Unocal No 2672**	LOCATION: **1075 Santa Rosa Avenue, Santa Rosa, California**		
PROJECT NUMBER: **06940-268-120**			
DRILLING CONTRACTOR / DRILLER: **Gregg Drilling & Testing / Robert / Trevor**	LOGGED BY: **Will Speth**		
DRILLING EQUIPMENT / METHOD: **BK-61&BK-53 / Mud-Rotary&HSA**	BIT SIZE / BIT TYPE: **15-inch / Auger**	SAMPLING METHOD: **SS 2 in. O.D.**	START-FINISH DATE: **4/27/04 - 5/5/04**

CASING MATL. / DIAMETER	SCREEN: TYPE	MATL.	TOTAL LENGTH	DIA.	SLOT SIZE
Sch. 40 PVC/2 in.	**Slotted**	**PVC**	**5**	**2 in.**	**0.020**

ELEVATION OF: (FT.)	GROUND SURFACE	TOP OF WELL CASING	TOP & BOTTOM SCREEN	GW SURFACE	DATE
	155.80		**105.80 / 70.80**		

NORTHING	EASTING	LATITUDE	LONGITUDE	DATUM
1918352.7	**6357372**	**38.4276182**	**-122.7131359**	**MSL**



Visual Description

ASPHALT SURFACE 2.5-inches thick

FAT CLAY: Dark brown-black, medium to high plasticity, moist, stiff. (CH)
color change to medium reddish-brown, increasing amount of silt

LEAN CLAY w/SILT: yellowish brown , dry, nonplastic, hard. (CL)

CLAYEY GRAVEL w/SAND: Medium brown,sand medium to coarse grained, gravel subangular to subrounded, 1/4 to 1/2" diameter., nonplastic, wet, very dense. (GC)

grades to gravel up to 2-inch diameter

POORLY GRADED SAND: reddish-brown, fine and coarse skip graded, saturated, medium dense. (SP)

SILTY CLAY: greensih-gray to tan, low plasticity, moist, hard. (CL)

WELL GRADED SAND WITH GRAVEL: medium brown, fine to coarse grained, subangular to subrounded gravel, max diameter 3/8" diameter. (SW)

LEAN CLAY

CLAYEY SILT: tan to greenish-gray, trace coarse grained sand, low plasticity, moist, hard. (ML)

POORLY GRADED SAND WITH SILT: medium brown, fine and coarse skip graded sand, subrounded, saturated, very dense. (SP)

WELL GRADED SAND WITH SILT: medium brown, fine medium and coarse grained sand, saturated, very dense. (SW)

SANDY GRAVEL: medium brown, fine grained sand, gravel subangular to subrounded, 1/4 to 1 1/2" diameter, saturated, very dense. (GP)

WELL GRADED SAND WITH SILT: medium brown, fine medium and coarse grained sand, saturated, very dense. (SW)

POORLY GRADED SAND WITH SILT: medium brown, fine and coarse skip graded sand, subrounded, saturated, very dense. (SP)

CLAYEY SILT: medium brown, low plasticity, moist, hard. (CL)

POORLY GRADED SAND WITH SILT: Medium brown, medium to coarse grained sand, subangular to subrounded, nonplastic, saturated, very dense. (SP)

POORLY GRADED SAND WITH GRAVEL: medium brown, medium to coarse grained sand, subangular to subrounded gravel, 1/4 to 1 1/2" diameter gravel, saturated, very dense. (SP)

CLAYEY SAND: Medium brown, fine and coarse grained skip graded sand, saturated, very dense.

Depth (feet)	Blow Counts	Sample ID	OVM Values (ppm)
10	3 / 7 / 10	MW-12-10	0
15	12 / 20 / 24	MW-12-15	0
20	8 / 24 / 39	MW-12-20	0
25	12 / 32 / 34	MW-12-25	0
30	6 / 8 / 15	MW-12-30	3
35	7 / 17 / 20	MW-12-35	3
40	6 / 16 / 50-4"	MW-12-40	0
45	7 / 17 / 35	MW-12-45	0
50	13 / 35 / 40	MW-12-50	0
55	10 / 29 / 50-5"	MW-12-55	0
60	30 / 50 / 50-5"	MW-12-60	0
65	17 / 20 / 27	MW-12-65	0
70	8 / 50-5"	MW-12-70	0
75	14 / 26 / 50-5"	MW-12-75	0
80	11 / 38 / 45	MW-12-80	0
85	23 / 50-6"	MW-12-85	0

WELL CONSTRUCTION LOG

BOREHOLE NUMBER	
MW-13A/B	
PROJECT NAME: Unocal No 2672	LOCATION: 1075 Santa Rosa Avenue
PROJECT NUMBER: 06940-268-120	Santa Rosa, California

ENSR Corporation, Inc.
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Depth (feet)	(continued)	Graphic Log	Visual Description	Blow Counts	Depth (feet)	Sample ID	OVM Values (ppm)
	THREADED BOTTOM CAP		(SC) Bottom of borehole at 85 feet.				

Page 1 of 2

WELL CONSTRUCTION LOG

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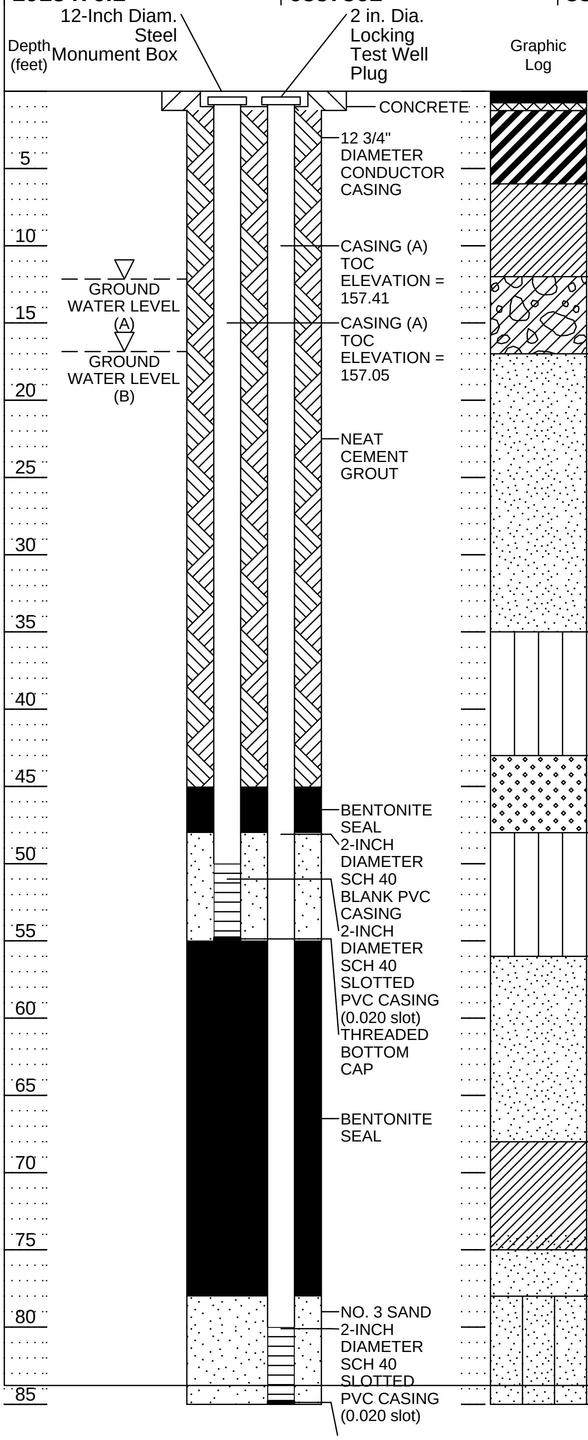
BOREHOLE NUMBER	**MW-14A/B**
PROJECT NAME	**Unocal No 2672**
PROJECT NUMBER	**06940-268-120**
LOCATION	**1075 Santa Rosa Avenue, Santa Rosa, California**
DRILLING CONTRACTOR / DRILLER	**Gregg Drilling & Testing / Robert / Trevor**
LOGGED BY	**Will Speth**
DRILLING EQUIPMENT / METHOD	**BK-61&BK-53 / Mud-Rotary&HSA**
BIT SIZE / BIT TYPE	**15-inch / Auger**
SAMPLING METHOD	**SS 2 in. O.D.**
START-FINISH DATE	**4/27/04 - 5/5/04**
CASING MATL. / DIAMETER	**Sch. 40 PVC/2 in.**

SCREEN: TYPE **Slotted** MATL. **PVC** TOTAL LENGTH **5** DIA. **2 in.** SLOT SIZE **0.020**

ELEVATION OF: (FT.)	GROUND SURFACE	TOP OF WELL CASING	TOP & BOTTOM SCREEN	GW SURFACE	DATE
	157.49		107.49 / 72.49		

NORTHING	EASTING	LATITUDE	LONGITUDE	DATUM
1918476.1	6357361	38.4279567	-122.7131776	MSL



Visual Description

ASPHALT SURFACE 2.5-inches thick

FAT CLAY: Black-brown, high plasticity, moist, stiff. (CH)
color change to reddish-brown

SILTY CLAY: medium brown, medium plasticity, moist, stiff. (CL)
color change to: greenish-gray

CLAYEY GRAVEL WITH SAND: greenish gray, nonplastic, fine and coarse grained sand, subangular to subrounded gravel, 1/4 to 1/2 diameter, saturated, dense. (GC)

POORLY GRADED SAND WITH GRAVEL AND CLAY: medium brown to greenish-gray, fine and coarse skip graded sand, gravel subrounded, 3/8 to 1 1/2" diameter, saturated, very dense. (SP)

SILT: Tan to medium brown, trave 1/4"diameter subrounded gravel, wet, hard. (ML)

WELL GRADED SAND: red-oxide brown, fine medium and coarse grained sand, saturated, very dense. (SW)

SANDY SILT: Tan, nonplastic, coarse grained sand, wet, hard. (ML)

POORLY GRADED SAND WITH GRAVEL: Medium brown, fine and coarse grained skip graded sand, saturated, very dense. (SP)
appreciably more gravel subangular to subrounded 1/4 to 1/2" diameter.

LEAN CLAY: reddish-brown, low plasticity, moist, hard. (CL)

POORLY GRADED SAND WITH SILT: Medium brown, fine grained sand, saturated, very dense. (SP)

SILTY SAND WITH GRAVEL: medium brown, nonplastic, fine and coarse grained sand, subrounded gravel, 3/8" diameter, wet, very dense. (SM)

Bottom of borehole at 85 feet.

Blow Counts	Depth (feet)	Sample ID	OVM Values (ppm)
2 5 7	10	MW-14-10	50
6 10 11	15	MW-14-15	299
12 19 23	20	MW-14-20	124
18 21 34	25	MW-14-25	2
19 22 41	30	MW-14-30	0
10 17 7	35	MW-14-35	0
13 23 30	40	MW-14-40	0
6 21 30	45	MW-14-45	0
10 21 31	50	MW-14-50	0
8 15 20	55	MW-14-55	0
15 50-6"	60	MW-14-60	0
17 50-6"	65	MW-14-65	0
9 19 27	70	MW-14-70	0
8 15 28	75	MW-14-75	0
18 50-6"	80	MW-14-80	0
50-6"	85	MW-14-85	0

WELL CONSTRUCTION LOG

BOREHOLE NUMBER	
MW-14A/B	
PROJECT NAME: **Unocal No 2672**	LOCATION: **1075 Santa Rosa Avenue**
PROJECT NUMBER: **06940-268-120**	**Santa Rosa, California**

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Depth (feet)	(continued)	Graphic Log	Visual Description	Blow Counts	Depth (feet)	Sample ID	OVM Values (ppm)
	THREADED BOTTOM CAP						

WELL CONSTRUCTION LOG

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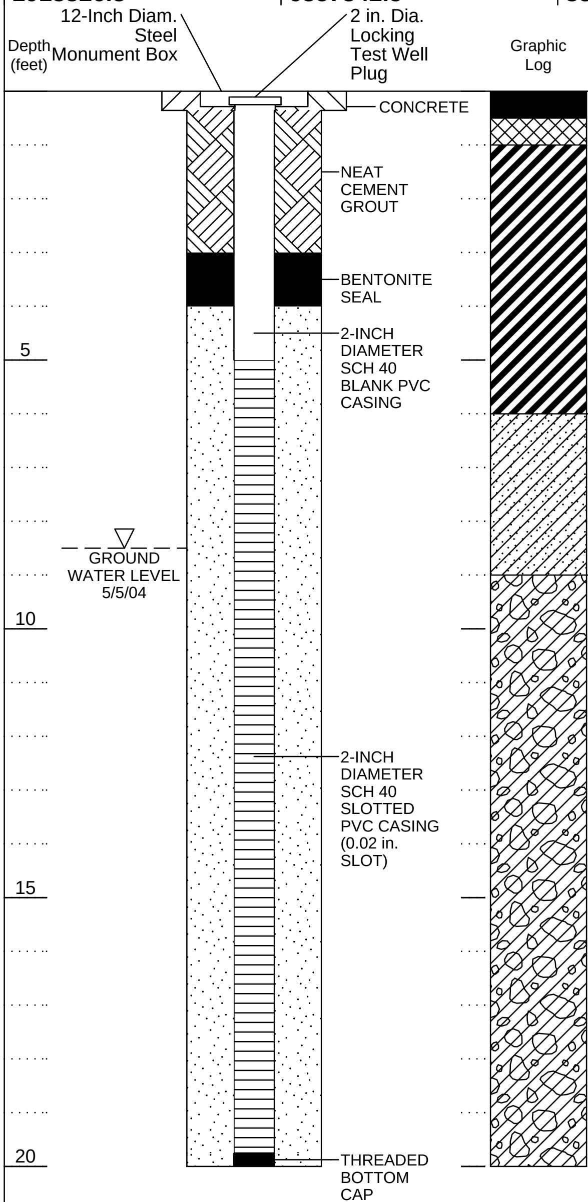
BOREHOLE NUMBER	**MW-15**
PROJECT NAME	**Unocal No 2672**
PROJECT NUMBER	**06940-268-120**
LOCATION	**1075 Santa Rosa Avenue, Santa Rosa, California**
DRILLING CONTRACTOR / DRILLER	**Gregg Drilling & Testing / Robert / Trevor**
LOGGED BY	**Will Speth**
DRILLING EQUIPMENT / METHOD	**BK-61&BK-53 / Mud-Rotary&HSA**
BIT SIZE / BIT TYPE	**15-inch / Auger**
SAMPLING METHOD	**SS 2 in. O.D.**
START-FINISH DATE	**5/5/04 - 5/5/04**
CASING MATL. / DIAMETER	**Sch. 40 PVC/2 in.**
SCREEN: TYPE	**Slotted**
MATL.	**PVC**
TOTAL LENGTH	**5**
DIA.	**2 in.**
SLOT SIZE	**0.020**

ELEVATION OF: (FT.)	GROUND SURFACE	TOP OF WELL CASING	TOP & BOTTOM SCREEN	GW SURFACE	DATE
	155.30		**150.30 / 135.30**	**146.80**	**5/5/04**

NORTHING	EASTING	LATITUDE	LONGITUDE	DATUM
1918326.8	**6357342.5**	**38.4275464**	**-122.7132383**	**MSL**



Visual Description

ASPHALT SURFACE: 2.5-inches thick.

FAT CLAY: Black-brown, medium to high plasticity, moist, stiff. (CH)

color change to medium brown

CLAYEY SAND: Green-blue, non-plastic, fine to medium grained sand, moist. (SC)

CLAYEY GRAVEL WITH SAND: Reddish-brown, fine and coarse skip graded, subangular to sub rounded, gravel 3/8 to 1/2" diameter, saturated, dense. (GC)

Bottom of borehole at 20 feet.

Blow Counts	Depth (feet)	Sample ID	OVM Values (ppm)
5, 5, 8		MW-15-6.5	3
15, 24, 23	10	MW-15-10	2
22, 23, 29	15	MW-15-15	3
22, 50-6"	20	MW-15-20	2.2